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ASSESSING IMPACT OF EXPOSURE TO CYBERPHYSICAL SYSTEMS ON STUDENT INTEREST IN INFORMATION TECHNOLOGY CAREERS

For the degree of Master of Science

Is approved by the final examining committee:

Prof. Alka R. Harriger
Chair

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Prof. Dawn Laux, PhD

Prof. Alejandra J. Magana, PhD

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Approved by Major Professor(s): Prof. Alka R. Harriger

Approved by: Prof. Jeffrey L. Whitten 4/15/2015

Head of the Departmental Graduate Program Date

ASSESSING IMPACT OF EXPOSURE TO CYBERPHYSICAL SYSTEMS ON STUDENT INTEREST IN INFORMATION TECHNOLOGY CAREERS

A Thesis

Submitted to the Faculty

of

Purdue University

by

Mayari I Serrano Anazco

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

May 2015

Purdue University

West Lafayette, Indiana

To God.

For my husband Diego.

For my family: Marco, Lourdes, Yamara, Dayuma, Brownie, and Toby.

In loving memory of Maria Ercilia.

ACKNOWLEDGEMENTS

The author would like to thank Professors Bradley Harriger and Alka Harriger who facilitated the technology used to implement the project's device, and also provided valuable guidance throughout the project.

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LIST OF ABBREVIATIONS

AWG: American Wire Gauge.

CIT: Computer and Information Technology.

CLAIMiT: Communicating Leadership and Advancing Innovation for Minorities in Technology.

CS: Computer Science.

CVTAE: Control-Value Theory of Achievement Emotions.

DC: Direct Current.

DOiT: Discovering Opportunities in Technology.

GSM: Global System for Mobile.

IoT: Internet of Things.

IRB: Institutional Review Board.

IT: Information Technology.

LCD: Liquid Cristal Display.

NO: Normally Open.

NSF: National Science Foundation.

RQ: Research Question.

SCCT: Social Cognitive Career Theory.

SIM: Subscriber Identity Module.

SMS: Short Message Service.

STEM: Science, Technology, Engineering, and Mathematics.

V: Volt.

WOWiT: Windows of Opportunity for Women in Technology.

GLOSSARY

Computational Thinking: “thought process of recognizing aspects of computation in the world that surrounds us, and applying tools and techniques from Computer Science to understand and reason about both natural and artificial systems and processes” (Grover & Pea, 2013, p. 39).

Computer programming: “use of symbolic commands arranged in an appropriate sequence to create a series of actions in order to instruct a computer’s behavior” (Kazakoff, Sullivan, & Bers, 2013, p. 248).

Constructivist pedagogy: “to build new knowledge based on existing knowledge and own experience” (Barak & Zadok, 2007, p. 290).

Emotions: “are seen as multi-component, coordinated processes of psychological subsystems including affective, cognitive, motivational, expressive, and peripheral physiological processes” (Pekrun, 2006, p. 316).

Interest: “is the extent to which an individual enjoys engaging with a set of tasks” (Scott & Ghinea, 2014, p. 124).

Internet of Things (also known as IoT): “network that inter-connects ordinary physical objects with the identifiable addresses so that provides intelligent services” (Hua-Dong, 2011, p. 920).

Self-concept: “self-perceptions that are formed through experience with interpretations of one's environment" (Scott & Ghinea, 2014, p. 124).

Wearable Computing/Wearable Devices: “wearable devices allow hands-free interaction or by at least minimizing the use of keyboard or pen input when using the device. This is achieved by devices that are worn on the body” (Freitas & Levene, 2006).

ABSTRACT

Serrano Anazco, Mayari I. M.S., Purdue University, May 2015. Assessing Impact of Exposure to Cyberphysical Systems on Student Interest in Information Technology Careers. Major Professor: Alka Harriger.

The main purpose of this project is to determine if the use of Information Technology (IT) tools, specifically cyberphysical devices, in outreach sessions will promote interest of young individuals in pursuing IT careers. The Diversity office of Purdue's College of Technology offers a number of outreach sessions to a variety of target populations throughout the year. Each department in the college has an opportunity to present a session related to a field of study offered by the department. The research was carried out thru the Spring 2015 semester during the DOiT and Vision outreach programs offered through the college's Diversity office. The participants of both the DOiT and Vision programs are 11th grade students who are exploring technology majors. The researcher directed the sessions for the Computer and Information Technology department and used a cyberphysical device to introduce students to programming. Participants of the outreach session were requested to complete two Internet-based surveys. The responses were processed using a paired t-test, two-sample t-test, and correlational statistics. The research sugested that when comparing the additional interaction with a cyberphysical device to a session that only used the simulation tool to visualize the

outcomes, there was no statistically-significant increase in student interest in IT with the addition of the device. A weak linear relationship was found to be present between interest and self-beliefs.

CHAPTER 1. INTRODUCTION

1.1 Background and Significance

Augustine (2007) stated: "Since the Industrial Revolution, the growth of economies throughout the world has been driven largely by the pursuit of scientific understanding, the application of engineering solutions, and continual technological innovation" (p.41). However, even though the United States has almost tripled the number of granted bachelor's degrees, science, technology, engineering, and mathematics (STEM) fields did not meet the expectations needed to cover the demand of the country for qualified professionals (Maltese & Tai, 2011). The creation of new jobs coupled with retiring baby boomers is expected to create over three million job openings in STEM fields by 2018 (Maltese & Tai, 2011).

In general, computing and technology-related fields suffer from underrepresentation of women and minorities, like most STEM fields as shown in Figure 1.1. The United States awarded 1,791,046 bachelor's degrees for the period 2011-2012, and only 47,384 corresponded to computer and information sciences and support services, representing 2.6% of the total degrees awarded (National Center for Education Statistics, 2013). Statistics relative to women seem even more concerning because they represent only 18.17% (8,611) of the total for the field and only 0.48 % of all degrees awarded

(National Center for Education Statistics, 2013). 17,173 (36.24%) bachelor degrees were awarded to unrepresented minorities (National Center for Education Statistics, 2013).

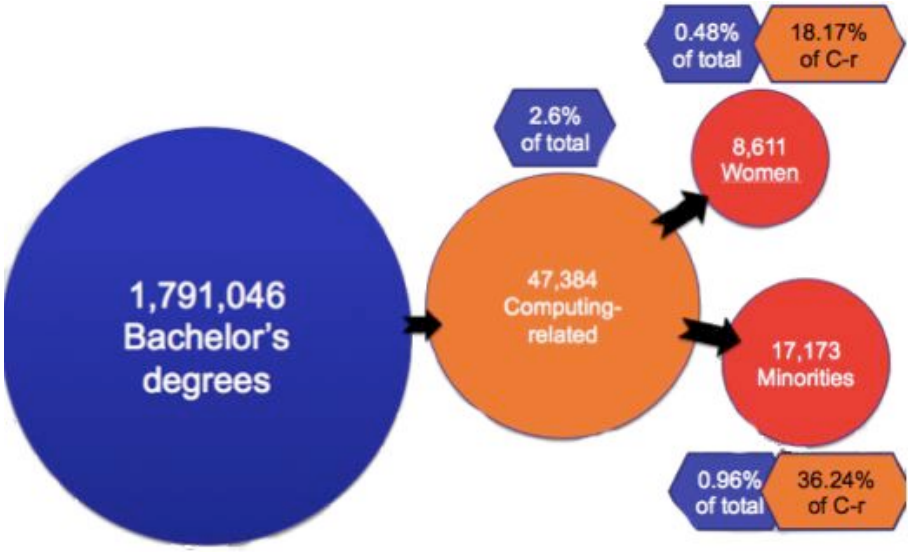

Figure 1.1 Graphical representation of the statistics for computing and computing related fields (National Center for Education Statistics, 2013).

However, there is an increasing demand for computing-related professionals; it is projected that for the period 2008-2018, there will be 762,700 new job openings (Lacey & Wright, 2009).

In order to change this situation, the President's Council of Advisors on science and technology (2010) prioritized the importance of incorporating women and minorities in to STEM fields. In fact, the nation should consolidate its efforts to improve women's preparation and inspiration practices in the field. Outreach sessions and workshops can provide an inspirational environment in which participants can learn and interact with technology (Ngai, Chan, Cheung, & Lau, 2010).

1.2 Statement of Purpose

Information is a relevant factor that influences career choice. Availability of relevant facts about a particular field will create new career possibilities for an individual. However, it is necessary to emphasize that information is just one of the many factors that contribute to career choice outcomes (Dimitriadi, 2013).

To increase the number of people in STEM fields, it is necessary to implement recommended social and educational initiatives (Technology, President's Council of Advisors on Science and Technology, 2010). Additionally, it is critical to include women and minorities in these initiatives (Dimitriadi, 2013; Technology, President's Council of Advisors on Science and Technology, 2010).

The main purpose of this project was to determine if outreach sessions that show the programming of physical devices influence interest in Information Technology (IT) fields or generate changes in career choices.

1.3 Research Question

The imperative need to encourage young individuals to pursue careers in STEM fields leads to the following research questions:

1. Does interacting with a physical device programmed by the student increase his/her interest in pursuing Information Technology fields of study?
2. What are students' self-beliefs about Information Technology?
3. What is the relationship between students' interest in Information Technology fields and their self-beliefs?

1.4 Scope

Dick and Rallis (1991) have established the following: “A student's career goal directly shapes his or her perception of both the intrinsic and extrinsic value of academic tasks. This perception of task value has, in turn, a direct effect on the student's academic choices, performance, and persistence” (p. 282). This project focus was on an extracurricular academic activity and the influence of including IT tools such as cyberphysical devices.

1.5 Assumptions

This study presented the following assumptions:

- The participants provided true and thoughtful responses to the survey questions.
- Individuals’ participation in the outreach activity creates a good environment to learn and interact with Information Technology artifacts.
- The outreach devices worked properly every time.
- The time allowed for each outreach session was sufficient to complete all the planned activities.
- The research methodology used in this project was effective to answer the raised research question.

1.6 Limitations

The research on this project presented the following limitations:

- The research assessed the attitude towards Information Technology immediately after outreach exposure.
- Participants voluntarily filled out the surveys.

- The study was dependent on participants' willingness to interact with the cyberphysical device.
- Time frame allowed for the outreach session's activities was limited.

1.7 Delimitations

The study was delimited to the following:

- The time frame of one semester was needed to carry out the outreach sessions and conduct the research.
- Construction of the device relied on availability of the Phoenix Contact nanoNavigator software and nanoLine microcontroller, and miscellaneous electronic components.
- Only one demo device was used in the treatment groups.

1.8 Summary

In this chapter the author has presented an overview of STEM's importance in the United States. Additionally, this chapter shared background and significance, statement of purpose, research question, scope, assumptions, limitations, and delimitations of the research study.

CHAPTER 2. REVIEW OF LITERATURE

This chapter presents information about science, technology, engineering, and mathematics (STEM) education in the United Sates, ways to address the problem, and technology that could be applied in outreach activities.

2.1 Science, Technology, Engineering, and Mathematics (STEM) historic scenario in the United States

The Soviet Union's success in launching Sputnik in 1957 prompted the United States to commence a 10-year effort to recruit and educate the country's best and brightest individuals to carry out a race in science and engineering innovation. This period of scientific and technological innovation created new businesses and job opportunities. The nation's prosperity was grounded on excellence in STEM along with investments in research and development (National Science Foundation, 2010).

The total amount of undergraduate degrees conferred in the United States almost tripled by 2011 in relation to 1971 records. However, the number of STEM degrees awarded did not follow the same pattern (Maltese & Tai, 2011).

It is projected that the creation of new job openings after the imminent retirement of the baby-boom generation workforce will create over three million new jobs in STEM fields by 2018. Diverse initiatives have been implemented to avoid shortage of STEM professionals (Maltese & Tai, 2011).

Computing and technology fields present a small number of enrollments and graduates (Ngai, Chan, Cheung, & Lau, 2010). Moreover, these fields indicate underrepresentation of women and minorities. The United States awarded 1,791,046 bachelor's degrees for the period 2011-2012, and 47,384 correspond to "Computer and information sciences and support services", representing 2.6% of the total degrees. Additionally, statistics relative to women seem even more concerning since they represent only 18.17% (8,611) of the total for the field (National Center for Education Statistics, 2013). 17,173 (36.24%) bachelor degrees were awarded to unrepresented minorities (National Center for Education Statistics, 2013). Lack of interest in Computer Science (CS) and Information Technology (IT) has persisted even though there is an increasing demand for IT professionals (Papastergiou, 2008).

An important factor in the United States' innovations on science and technology has been the ability to attract and retain foreign workers. However, global competition over acquiring STEM professionals has increased, so it is essential to find new ways to attract foreign talent and increase domestic human capital (National Science Foundation, 2010).

The National Science Foundation (2010) emphasized an important certainty: "The U.S. education system too frequently fails to identify and develop our most talented and motivated students who will become the next generation of innovators" (p.5). This reality opens a window of opportunity to improve the strategies and develop new ways to reach individuals with STEM potential.

2.1.1 Pathway towards STEM careers

In order to back up their decisions on STEM, education policy makers used the pipeline metaphor as pivot. The traditional pipeline representation assumes that the "flow" towards becoming an STEM professional follow a unique route. The pipeline thinking suggests that there are two specific factors that seem to increase the probability of becoming an STEM professional: "Develop a specific 'early' interest in pursuing a career in a STEM field and earn credits in a calculus course while still in high school" (Cannady, Greenwald, & Harris, 2014, p.454). However, out of five STEM professionals three of them presented just one of the factors and 16% neither. This data suggests that multiple pathways exist, which supports the need for a wider spectrum of necessary policies that should be applied in order to increase the number of STEM professionals (Cannady, Greenwald, & Harris, 2014).

Key elements to develop STEM interest are: training in science and math, access to hands on activities, having STEM mentors and role models, peer interest communication and proper school-based learning. Additionally, the career pathway is influenced by family variables and personality (Brody, 2006).

Multiple researchers have linked interest (I) in STEM with taking calculus (C) classes in high school. However, Cannady, Greenwarld, and Harris (2014) presented a compilation of professionals' paths towards joining the STEM workforce. Figure 2.1 emphasizes on the individuals' path rather than in milestones, here is where outreach could become an important trend setting towards developing interest in STEM.

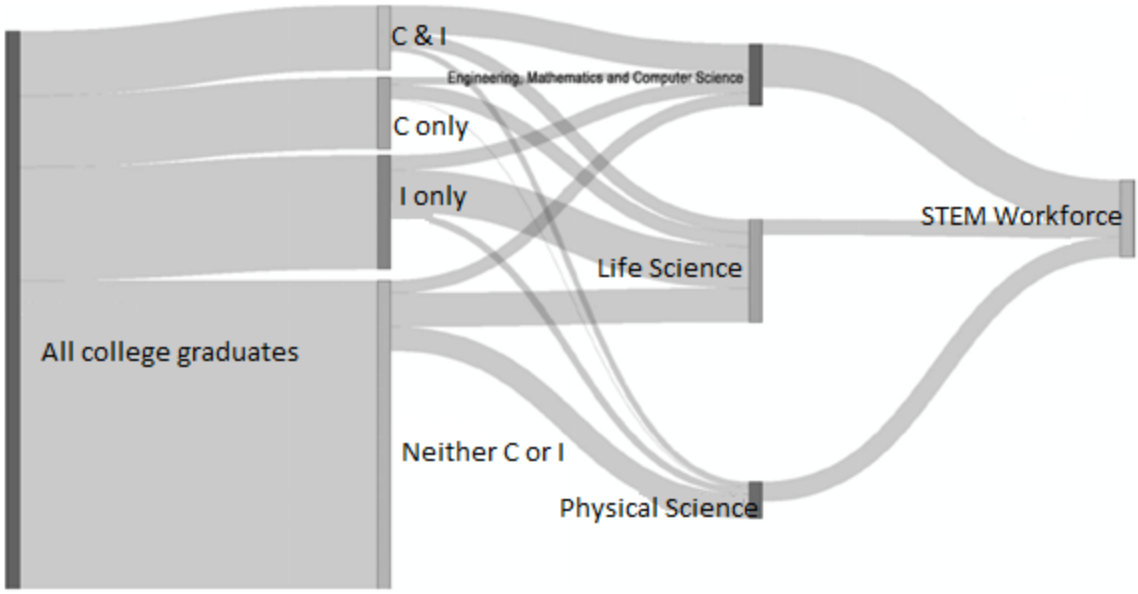

Figure 2.1 Sankey diagram of college degree, and STEM workforce (C=calculus, I=interest) (Cannady, Greenwald, & Harris, 2014, p. 455).

2.1.2 K-12 STEM Outreach

The President's Council of Advisors on science and technology in its 2010 report stated that part of the STEM crisis could be attributed to lack of proficient teachers on STEM subjects and absence of inspirational attitudes towards the fields. One recommendation to overcome the inspiration deficit is to "create opportunities for inspiration through individual and group experiences outside the classroom" (President's Council of Advisors on Science and Technology, 2010, p.46).

The President's Council of Advisors on Science and Technology (2010) prioritized the importance of incorporating woman and minorities in STEM fields. Moreover, they stated that the nation should improve its preparation and inspiration practices in the field. The Obama Administration launched, in 2009, an initiative called "Educate to Innovate" which tries to provide American students with skills needed to

succeed in STEM fields (Educate to Innovate, 2015). Industry has also joined this cause. For example, in 2010 Exxon Mobil introduce "Change Equation" which focuses on increasing the number of qualified STEM teachers (Change the Equation, 2015).

The main goal of STEM outreach activities is to foster scientific curiosity and interest as well as generate awareness about the fields. Additionally, these activities must find innovative ways of making topics approachable and, when possible, tangible (Kallback-Rose, Antolovic, Ping, Seiffert, Miller, & Steward, 2012).

The College of Technology at Purdue University offers the following outreach camps, on the West Lafayette campus:

- Communicating Leadership and Advancing Innovation for Minorities in Technology (CLAIMiT)
- Discovering Opportunities in Technology (DOiT)
- STEM ABC Camp
- Technology Advanced Girl Scouts (TAGS)
- Technology Expanding All Minds (TEAM)
- Turned onto Technology and Leadership (TOTAL)
- Vision Camp
- Windows of Opportunity for Women in Technology (WOWiT)

These programs offer hands-on activities, and social activities to introduce technology innovation applied in a variety of ways (Purdue-College of Technology, 2014).

Early positive experiences towards STEM might generate the necessary interest to carry students on the pathway to obtain an STEM degree (Maltese & Tai, 2011). Many outreach activities can be carried out with a small budget and in collaboration with higher

education institutions or industries (Kallback-Rose, Antolovic, Ping, Seiffert, Miller, & Steward, 2012). Other research also indicates that outreach sessions and workshops represent an inspirational environment in which participants can learn and interact with technology (Ngai, Chan, Cheung, & Lau, 2010).

The use of innovative new technology in outreach activities generates awareness, creativity, and enthusiasm in participants (Ngai, Chan, Cheung, & Lau, 2010).

2.2 Educational Computing Tools

Enthusiasm towards teaching programming concepts to children had a boost in in late 1970s and 1980s with the availability of personal computers. Several schools used Logo or Basic to introduce programming to students. However, this initial enthusiasm shifted direction on to other practices. Nowadays, there is a widespread usage of computers by children, but only a small fraction of them learn to program (Resnick, et al., 2009).

Given that educational computing tools are mainly designed for the use of novices they must possess a wide range of error tolerance coupled with low entry barrier (Ngai, Chan, Cheung, & Lau, 2010).

2.2.1 Visual Programming Languages

Visual programming languages use diagrams of blocks to create program scripts. These kinds of languages make software design similar to hardware design (Schaefer, 2011).

Visual programming languages remove unnecessary syntax for K12 students allowing them to acquire computational concepts more easily and concentrate on the algorithm design. Additionally, students can see the outcomes of their programming in

the form of animated objects (Lye & Ling, 2014) ; (Charntaweekhun & Wangsiripitak, 2006).

2.2.1.1 Flowchart Programming

Using a flowchart to represent the process of solving a problem makes understanding the logic easier. When using flowcharts the programmer organizes the necessary steps to solve a given problem (Charntaweekhun & Wangsiripitak, 2006).

2.2.2 Physical Computing

According to Kato (2010), physical computing is "the interaction with physical objects by controlling sensors and actuators attached to microcontrollers" (p.1). Physical computing learning environments use tangible components to develop and implement a task; this represents an advantage over virtual learning environments. Additionally, research shows that tangible environments might facilitate more natural and effective learning (Ngai, Chan, Cheung, & Lau, 2010).

2.3 Internet of Things

There are numerous definitions of the Internet of Things (IoT), but the author will use just one of them, which was presented by Swan (2012): "Internet of Things is the general idea of things, especially everyday objects, that are readable, recognizable, locatable, addressable, and controllable via the Internet - whether via RFID, wireless LAN, wide-area network, or other means" (p. 920).

Over the past 10 years IoT devices and applications have experienced an accelerated growth in popularity and demand as shown in Figure 2.2 (Swan, 2012).

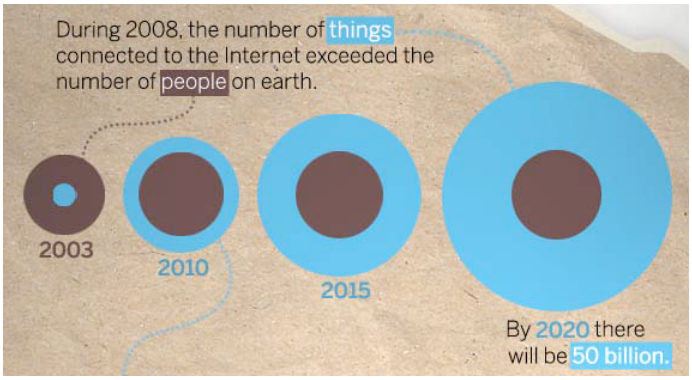

Figure 2.2 Growth of interconnected devices (Swan, 2012, p. 219).

There are numerous commercially available sensors in the market that could be used to track movement, light, electrical signals, temperature, and heart rate variability.

2.3.1 Wearable Computing Devices

Over time technology innovation has created new applications for information and manufacturing technologies (Finger, et al., 1996). However, many of these technologies were restricted to research and governmental entities (Ngai, Chan, Cheung, & Lau, 2010).

These devices permit hands-free interaction when they are worn on the body. However, a wearable device can also refer to devices that have minimized the use of keyboard input (Freitas & Levene, 2006).

Probably the most commonly-used wearable computing devices are smart watches and wristband sensors. However, over the last couple of years wearable textiles have increased in popularity (Swan, 2012).

Purdue University researchers developed an example of wearable computing devices. They created an ultra-stretchable electronic surface. The device can extend its size by 500%. The materials used to build it were a polyethylene terephthalate sheet that

integrated with wire using a sewing machine and water-soluble thread. This device was used to track the enlargement of an inflatable urinary catheter balloon (Rahimi, Ochoa, Yu, & Ziaie, 2014).

A wearable-computing educational platform was successfully implemented by Ngai, Chan, Cheung, and Lau (2010). Using Arduino and Lilypad for Arduino to create an interactive t-shirt called "Teeboard". They made the following recommendations for a wearable computing platform design:

- Select a programming language that can be easily learned by the student.
- Select durable materials that could be reused.
- Establish user-friendly construction parameters.
- Allow rapid experimentation.
- The programming activity should include easily debuggable steps.
- Activities must challenge participant's creativity and problem solving skills.
- Deliver a syllabus of the activity to participants.

Basic technology, like Arduino, proved to be a robust tool to implement wearable computing devices in outreach settings (Ngai, Chan, Cheung, & Lau, 2010).

The main purpose of this study is to determine if cyberphysical technology generates interest in IT when individuals interact with the physical device. As previously stated, this technology was successfully integrated in learning and outreach environments. Additionally, easy to use software and hardware could be used to develop high performance and innovative devices.

2.4 Summary

This chapter provides an insight of previous work in the field of STEM education and how IT tools have been already incorporated. STEM outreach and education has been a priority subject for the government, industry, and academic institutions since 1957.

CHAPTER 3. THEORETICAL FRAMEWORK

This study implemented a combination of Social Cognitive Career Theory and Control-value theory of achievement emotions in its assessments and design of research questions.

3.1 Social Cognitive Career Theory

This study considered the influences that may affect students' career choices based on the Social Cognitive Career Theory (SCCT). This theory tries, according to the work of Lent, Brown and Hackett (2012): "To trace some of the complex connections between persons and their career related contexts, between cognitive and interpersonal factors, and between self-directed and externally imposed influences on career behavior" (p. 456).

The SCCT is based on the principle that a mixture of extrinsic experiences and intrinsic interests establish student's career aspirations. This theory states that career choices and aspirations are a result of complex interactions between:

- Person
- Environment
- Behavior (Maltese & Tai, 2011).

The SCCT model denotes that self-efficacy beliefs and outcome expectations work together to create career interests. In other words, people tend to express interest in

a career if they consider that they will perform well and if it presents satisfactory outcomes (Lent, Brown, & Hackett, 2002). Additionally, this theory is grounded on constructivism by stressing that people's abilities are influenced by their own progress and surroundings (Lent, Brown, & Hackett, 2002). Figure 3.1 shows the SCCT model graphically.

More importantly, positive, career-related experiences coupled with aptitude to do well are likely to produce strong efficacy expectations and predispositions towards pursuing this career. On the other hand, a person unexposed to compelling and positive experiences in a field is unlikely to consider an academic future in it (Lent, Brown, & Hackett, 2002).

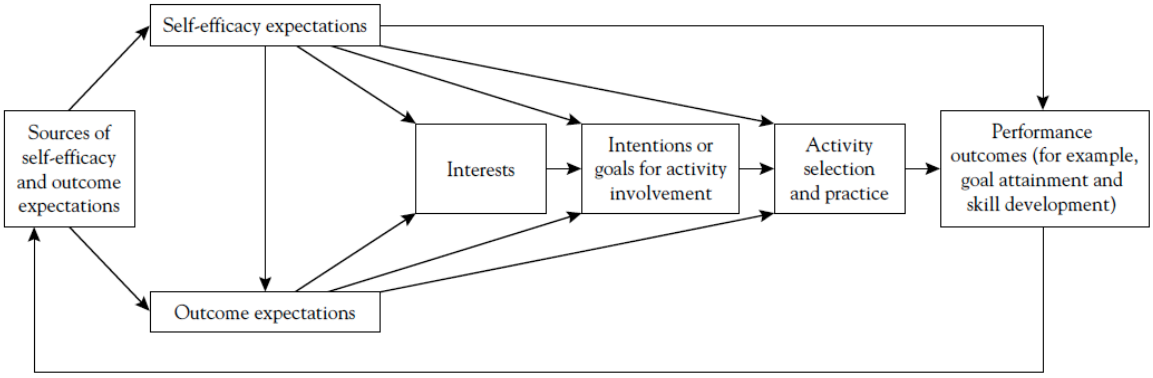

Figure 3.1 Model of how basic career interest develops over time (Lent, Brown, & Hackett, 2002, p. 266).

3.2 Control-Value Theory of Achievement Emotions

Control-Value Theory of Achievement Emotions (CVTAE) provides a comprehensive outline for the analyses of emotions related to learning activities (Pekrun, 2006). This learning theory encompasses the role of self-beliefs and emotions and their influence in future learning outcomes (Scott & Ghinea, 2014).

Emotions related to a learning context are inherent educational outcomes. Emotions "can affect students' interest, engagement, achievement, and personality development, as well as the social climate in classrooms and educational institutions" (Pekrun, 2006, pp. 333,334).

Control and value-related emotions such as interest and self-concepts are domain specific (Pekrun, 2006). This theory was used as a framework to develop an assessment used in introductory programming courses (Scott & Ghinea, 2014). The assessment was adapted for this specific study.

3.3 Summary

This chapter summarized relevant concepts about Social Cognitive Career Theory and Control-Value Theory of Achievement Emotions. Both theories were integrated in the quasi-experimental design of this project.

CHAPTER 4. TECHNICAL CONSIDERATIONS

4.1 Background

Numerous outreach activities had been developed and implemented using different technologies such as social media tools like Twitter, visual programming languages such as Scratch, Scratch 4 Arduino, nanoNavigator, and physical computing which included Arduino Board, Phoenix Contact Nanoline. The researcher selected the "Push-up contest" device to be used in the study after pondering the feedback from all of the previous types of outreach sessions.

4.2 Hardware

The Phoenix Contact Nanoline technology was chosen to develop and implement the device. It enables relay switching and control of basic input/output functions and programmable processes. The Nanoline components are compact, versatile, and relatively easy to wire and to program (Phoenix Contact, 2015).

Figure 4.1 Nanoline components (Phoenix Contact, 2015).

Figure 4.1 shows the 24-volt Nanoline base unit, an Ethernet module (left), and a digital module and an analog module used to provide additional input output channels (right).

The base unit has eight digital inputs, two analog inputs, and four relay digital output channels. An operator control panel was installed on the unit, which is used as an interaction interphase. This interphase allows displaying messages and reading the status of input/output states, registers, timers, counters, and flags (Phoenix Contact, 2015).

For the demo a Global System for Mobile (GSM) module was implemented. The GMS module allows SMS (Short Message Service) exchange between the microcontroller and the user (Phoenix Contact, 2015).

4.3 Software

The Nanoline microcontroller uses flowchart/ ladder-chart programming software to depict the program logic employed in the construction of scripts (Harriger & Serrano, 2014). The nanoNavigator software provides an easy and fast programming process of the microcontroller. Additionally, users do not need to have prior programming experience to work with it (Phoenix Contact, 2015).

The nanoNavigator software is a free flowchart programming tool downloadable from the Phoenix Contact website (https://www.phoenixcontact.com/online/portal/us?uri=pxc-oc-itemdetail:pid=2701221&library=usen&tab=1).

To construct the flowchart, the tool provides blocks to represent programming concepts, which are color and shape coded (Figure 4.2). Also, the tool has a built in simulation tool that may be used to dynamically observe and track program behavior

(Phoenix Contact, 2015). The simulation of the program script may be done without having the electrical components assembled or connected. This feature permits the user to observe the program inputs, outputs, messages, resisters, and timer's data. Moreover, the user is able to watch the flowchart's logic behavior (Harriger & Serrano, 2014).

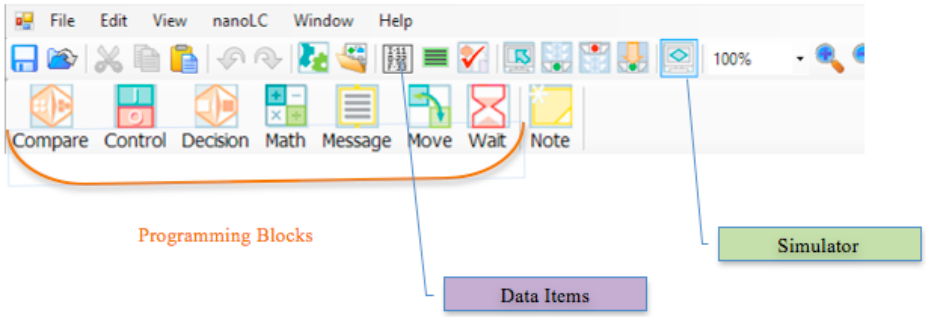

Figure 4.2 nanoNavigator software menu.

4.4 Technical Considerations

The device implementation required basic knowledge about circuit configuration. The inputs and outputs used were digital.

4.4.1 Game Logic

The device can work with or without using the GSM module. The user will have to select one of the options before accessing the game.

If the user chooses to enable GSM usage, the device will send a SMS message to the enabled cellphone numbers with instructions to reply with the command "START" to begin the game. The instructions will be displayed on the operator terminal LCD screen and sent via SMS. Players then assume the appropriate position to perform push-ups. Each sensor triggers both a different colored light to turn on as an output indicator of correct movement and a buzzer to sound as an audio indicator. An SMS message will be

sent to all enabled phones along with activity-related statistics. The user that completes fifteen (15) push-ups first wins the contest. If the user disables GSM usage, the game will start automatically and the messages will be displayed on the operator panel LCD.

The program script used to depict this logic in in Appendix A. Appendix F shows a detailed interaction diagram for the outreach session.

4.4.2 Components

The device uses three (3) digital inputs from the base unit (I0, I1, and I4) to read the signals from the proximity sensors and GSM signal. Additionally, four (4) digital outputs (Q0, Q1, Q2, and Q3) were used to operate the signaling lights, buzzer, and GSM signal. For details about the circuit configuration please refer to Appendix B. Also, a detailed list of the components used for the implementation is displayed on Table 4.1.

Table 4.1 *"Push-up contest" components.*

Component	**Quantity**
Nanoline base unit (24 V)	1
Operator terminal	1
Programming module	1
Serial Cable	1
Power supply (24 V DC)	1
Indicator light (NO Contact)	3
Communication module - NLC-COM-GSM – 2701344	1
Omnidirectional antenna - PSI-GSM/UMTS-QB-ANT – 2313371	1
SIM card	1
Terminal blocks	11
Jumpers	2
End cover	2
Power cable	1
Proximity sensor	2
Buzzer	1
Cellphone	1
Ferrules for 18 AWG	N/A
18 AWG Wire	N/A

4.5 Summary

This chapter summarized relevant technical information about the components used to develop and implement the project's demo named "Push-up contest". The device was developed and implemented using Nanoline components and nanoNavigator software.

CHAPTER 5. METHODS

The purpose of the study was to determine whether the exposure to cyberphysical devices during outreach sessions increment the interest of 11th grade students in Information Technology. The research questions proposed for this study were the following:

1. Does interacting with a physical device programmed by the student increase his/her interest in pursuing Information Technology fields of study?
2. What are students' self-beliefs about Information Technology?
3. What is the relationship between students' interest in Information Technology fields and their self-beliefs?

5.1 Participants

The Purdue College of Technology offers several outreach camps, such as Windows of Opportunity for Women in Technology (WOWiT), Communicating Leadership and Advancing Innovation for Minorities in Technology (CLAIMiT), Discovering Opportunities in Technology (DOiT), and the Vision Camp. The targeted population of the study are the participants of DOiT and the Vision camps, which are 11th grade students who are exploring technology majors. DOiT was scheduled for February 19 - 21and Vision for March 26 to 28. The CIT department actively participates in all

sessions as well. Commonly, each camp offers two or three back-to-back sessions of 50 minutes each. Table 5.1 contains the number of participants in each camp.

Table 5.1 *Number of participants in the DOiT and Vision outreach camps.*

Outreach Camp	Number of participants
DOiT	58
Vision	57

5.2 Data Collection Methods

For each camp the researcher randomly selected a session that interacted with the device (see Table 5.2 and 5.5). The design is classified as quasi-experimental because the treatment was randomly assigned, and the groups were previously conformed. The one control group was chosen randomly in each program. Pre and post surveys were used as the assessment instruments (Table 5.3 and 5.4).

Table 5.2 *Treatment assignation.*

Outreach Camp	Outreach session	Treatment
DOiT	8:30-9:20 am	Control group
	9:30 10:20 am	Treatment group
Vision	8:30-9:20 am	Control group
	9:30 10:20 am	Treatment group

5.2.1 Survey

The questionnaires were distributed online using Purdue Qualtrics system, survey software that is available for Purdue staff, faculty, and students.

The surveys collected demographic information about the students and data about the outreach session's impact. The pre-survey is comprised of eight (8) multiple choice demographic questions that will collect data about gender, school grade currently enroll in, race/ethnicity, education level of parents, and background. Additionally, the survey also included six (6) multiple-choice questions to gauge interest in IT (Table 5.3). The post-survey was comprised of fourteen (14) multiple-choice questions, two (2) open-ended questions, and the six (6) interest multiple choice questions present in the pre-survey (Table 5.4). To review the order in which the questions were presented to participants refer to Appendix C and D.

The surveys utilized two different Likert scales to assess the responses. A Likert scale of three stages was used for questions that require a yes, maybe, or no answer. Additionally, a different Likert scale of five stages was adopted to measure strongest level of disagreement to the strongest level of agreement (Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree).

Table 5.3 *Pre-survey questions, variables, and sources.*

Number	Type	Question	Variable	Source
Demographic Questions				
1	Multiple choice	What is your gender? a) Male b) Female	Gender	N/A
2	Multiple choice	In what grade are you currently enrolled? a) 10th grade b) 11th grade c) 12th grade	Grade	N/A

Table 5.3 Continued.

Number	Type	Question	Variable	Source
3	Multiple choice	What is your race/ethnicity? a) White/Caucasian b) African American/Black c) Native American d) Hispanic/Latino e) Asian f) Pacific Islander g) Multiracial h) Other: (Open)	Race / Ethnicity	N/A
4	Multiple choice	What is the highest education level of your father? a) Middle school or below b) High school c) Community college d) Four year college e) Masters level f) Doctorate level g) Other: (Open)	Family Background	N/A
5	Multiple choice	What is the highest education level of your mother? a) Middle school or below b) High school c) Community college d) Four year college e) Masters level f) Doctorate level g) Other: (Open)	Family Background	N/A
6	Multiple Choice – Likert Scale of 3	Do you plan to attend college?	N/A	N/A
7	Multiple Choice – Likert Scale of 3	Do you have a role model who uses Information Technology in his/her career?	Interest in IT	(Kier, Blanchard, Osborne, & Albert, 2013)
8	Multiple Choice – Likert Scale of 3	Do you plan to pursue a technology related career?	Interest in technology	(Kier, Blanchard, Osborne, & Albert, 2013)

Table 5.3 Continued.

9	Multiple Choice – Likert Scale of 3	Do you plan to pursue an Information Technology career?	Intent to pursue IT	N/A
IT Statements				
10	Multiple Choice – Likert Scale of 5	I'm familiar with Information Technology.	Interest in IT	N/A
11	Multiple Choice – Likert Scale of 5	I'm interested in careers from the Information Technology field.	Interest in IT	N/A
12	Multiple Choice – Likert Scale of 5	I use Information Technology daily.	Interest in IT	N/A
13	Multiple Choice – Likert Scale of 5	I think Information Technology is interesting.	Interest in IT	(Forssen, Lauriski-Karriker, Harriger, & Moskal, 2011)

Table 5.4 *Post-survey questions, variables, and sources*

Number	Type	Question	Variable	Source
IT Statements				
1	Multiple Choice – Likert Scale of 3	Do you plan to pursue an Information Technology career?	Intent to pursue IT	N/A
2	Multiple Choice – Likert Scale of 3	Do you plan to pursue a technology related career?	Interest in technology	(Kier, Blanchard, Osborne, & Albert, 2013)
IT Statements				
3	Multiple Choice – Likert Scale of 5	I'm familiar with Information Technology.	Interest in IT	N/A
4	Multiple Choice – Likert Scale of 5	I'm interested in careers from the Information Technology field.	Interest in IT	N/A
5	Multiple Choice – Likert Scale of 5	I use Information Technology daily.	Interest in IT	N/A

Table 5.4 Continued.

Number	Type	Question	Variable	Source
6	Multiple Choice – Likert Scale of 5	I think Information Technology is interesting.	Interest in IT	(Forssen, Lauriski-Karriker, Harriger, & Moskal, 2011)
7	Multiple Choice – Likert Scale of 5	I plan to use technology in my future career.	Intent to pursue IT	(Kier, Blanchard, Osborne, & Albert, 2013)
8	Multiple Choice – Likert Scale of 5	If I study Information Technology in college, I will be able to pursue many different types of careers.	Intent to pursue IT	(Kier, Blanchard, Osborne, & Albert, 2013)
9	Multiple Choice – Likert Scale of 5	I do well in activities that use technology.	Self-concept	(Kier, Blanchard, Osborne, & Albert, 2013)
10	Multiple Choice – Likert Scale of 5	I have a lot of self-confidence when it comes to computing courses.	Self-concept	(Forssen, Lauriski-Karriker, Harriger, & Moskal, 2011)
11	Multiple Choice – Likert Scale of 5	I am confident that I can solve problems by using Information Technology applications.	Self-concept	(Forssen, Lauriski-Karriker, Harriger, & Moskal, 2011)
12	Multiple Choice – Likert Scale of 5	I do **not** like using information technology to solve problems.	Self-concept	(Forssen, Lauriski-Karriker, Harriger, & Moskal, 2011)
13	Multiple Choice – Likert Scale of 5	I have a fixed level of technology aptitude, and not much can be done to improve it.	Technology Aptitude Mindset	(Scott & Ghinea, 2014)
14	Multiple Choice – Likert Scale of 5	I am able to learn new technologies.	Technology Aptitude Mindset	(Kier, Blanchard, Osborne, & Albert, 2013)
15	Multiple Choice – Likert Scale of 5	I can learn new things about technology, but I cannot change my basic attitude towards technology.	Technology Aptitude Mindset	(Scott & Ghinea, 2014)

Table 5.4 Continued.

Number	Type	Question	Variable	Source
Session feedback				
16	Multiple Choice – Likert Scale of 5	This session was informative.	N/A	N/A
17	Multiple Choice – Likert Scale of 5	This session was fun.	N/A	N/A
18	Multiple Choice – Likert Scale of 5	This experience incremented my interest in Information Technology.	N/A	N/A
19	Multiple Choice – Likert Scale of 5	Today's session impacted positively on y intentions of pursuing an Information Technology major in college.	N/A	N/A
20	Open-ended	Name one important take-away from this session.	N/A	N/A
21	Open-ended	Name one thing that can make this session better.	N/A	N/A

5.2.2 Validity and Reliability of the instrument

The author developed an assessment instrument to address the project research goals grounded in literature review and theoretical framework (see Table 5.3 and 5.4).

The variables (demographics, interest, intent to pursue IT, self-concept, technology aptitude mindset) were obtained from Kier, Blanchard, Osborne, and Albert (2013) STEM-CIS, Scott and Ghinea (2014) student' self-beliefs and Forssen, Lauriski-Karriker, Harriger, and Moskal (2011) IT assesment. Subject matter experts reviewed the assessment to provide construct validity.

5.3 Procedures

The participants were recruited by the Purdue College of Technology; the researcher was not involved in the student recruitment process.

Each session included many important activities. Table 5.5 presents a detailed timeline of the outreach session activities. Additionally, a detail interaction diagram for each treatment is presented in Appendix F. At the beginning of the session each student received a handout and a five (5)-digit randomly assigned identification code. The researcher used the identification code to link pre and post survey data. No identifiable data was used as part of this study. Furthermore, the random identification code was only be used as an internal identifier of the data. Additionally, the results of the analysis were reported in an aggregated form in which no user identification code was connected to the data.

During the outreach session the researcher briefly shared information about Information Technology (IT) careers and explain how the session is one small example of the broad range of things that are possible in IT.

Table 5.5 *Outreach agenda for control and treatment groups*

Control group		Treatment group	
Duration	Activity	Duration	Activity
5 min	Session pre survey	5 min	Session pre survey
5 min	Introductions & IT Background	5 min	Introductions & IT Background
15 min	Develop flowchart program	15 min	Develop flowchart program
10 min	Interact with simulator	10 min	Interaction with IoT device and simulator
5 min	Session Wrap-up, questions & answers	5 min	Session Wrap-up, questions & answers
5 min	Session post survey	5 min	Session post survey

The researcher then introduced participants to IT in each outreach session using a hands-on activity in which they will use programming to describe the functioning of a physical device. The development tool included a simulator to test the expected functionality of the device. All groups for both programs used the simulator to test the accuracy of their programs. Participants used the nanoNavigator Software, a flowchart-programming tool developed by Phoenix Contact. As an introduction to this software they followed along with the instructor individually to create a simple program to make a light go on and off.

Participants in the control group used the simulator to visualize the components behavior. On the other hand, participants in the treatment group interacted with the physical device. The cyberphysical device integrated electronic components that allow the user to track his/her movement; in this case participants performed push-ups.

5.4 Data Analysis

In this section the investigator will present the specific research questions that will shape the quantitative research. Additionally, the statistical methods used to process the data will be displayed.

5.4.1 Hypotheses

This study proposed the following hypotheses:

1. RQ: Does interacting with a physical device programmed by the student increase his/her interest in pursuing Information Technology fields of study?

   H_{o1}: Interacting with a physical device programmed by the students does not increase their interest in pursuing IT fields of study.

H_{a1}: Interacting with a physical device programmed by the students does increase their interest in pursuing IT fields of study

2. RQ: What are students' self-beliefs about Information Technology?
3. RQ: What is the relationship between students' interest in Information Technology fields and their self-beliefs?

H_{o3}: There is no relationship between students' interest in IT and their self-beliefs.

H_{a3}: There is a relationship between students' interest in IT and their self-beliefs.

5.4.2 Statistical Analysis

Participants' answers were downloaded from Qualtrics in a .csv format. The responses were then classified and grouped based on the variables. The variables are demographics, interest and intent to pursue IT, self-concept, and technology aptitude mindset. To analyze data the researcher used statistical software R.

To compare treatments a two-sample t-test was used; the pre-survey contains questions related to the interest variable to ensure homogeneity between the samples (Rogers & Creed, 2011; Rasch, Kubinger, & Moder, 2011). To compare pre and post interest the researcher used a paired t-test (Newman & Howse, 2007).

The correlation between interest and self-beliefs was carried out using correlational statistics to obtain a correlation coefficient (Kier, Blanchard, Osborne, & Albert, 2013). Three out of four questions related to the variable self-concept were listed as positive statements (Questions 7,8 and 9); the last question (Question 10) was itemized as a negative statement. To homogenize the responses, the score assignation was inverted

for the fourth question: Strongly Disagree=5, Disagree=4, Neither Agree nor Disagree=3, Agree=2, and Strongly Agree=1. On the other hand, the variable technology aptitude mindset possess two questions (Questions 11 and 13) as listed as negative statements, and one positive statement (Question 12). In this case the positive statement score was inverted.

5.5 Institutional Review Board (IRB)

Because the main components of the study were based on human interaction with surveys, an IRB exemption application was summited for approval. The IRB exception was accepted on the 13th of February 2015(see Appendix E).

Surveys were anonymous and voluntary for participants. Participants were recruited by the Purdue College of Technology; the researcher was not involved with the college's recruitment of participants for their programs.

5.6 Summary

This chapter contains information regarding research methods and procedures that will provide meaningful results so further analysis could be performed.

CHAPTER 6. RESULTS AND IMPLICATIONS

This chapter presents the results obtained in previous stages through administration of the DOiT and Vision programs.

6.1 Participation Rate

For the purpose of this research, participants that completed both surveys were considered eligible participants, so any responses from participants that completed just the pre or post survey were discarded.

Out of the 58 participants from DOiT program, 54 completed the pre-survey, and 42 completed the post-survey. From this sample universe, only the individuals that completed both surveys were taken into consideration for the study, a total of 41; 20 participants in the control group and 21 in the treatment group. In other words, 70.7% of the DOiT program participants were involved in this study.

From the 57 participants of the Vision program, 49 completed the pre-survey, and 46 the post-survey. 39 completed the pre and post serves, 21 were part of the control group, and 18 part of the experimental group. A total of 68.42% of the Vision program participants contributed with this study. Table 6.1 provides the participation rate data for both programs.

Table 6.1 *Participation Rate.*

	Sample Universe	Completed Pre-survey	Completed Post-survey	Both Surveys	Response Rate
DOiT	58	54	42	41	70.7%
Vision	57	49	46	39	68.42%

6.2 Demographic Statistical Analysis

The demographic information includes questions 9, 10,11, 12, and 13 of the pre survey (see Appendix C). 100% of the DOiT program and Vision program participants stated that they are 11th graders. 100% of the study participants from DOiT program identified themselves as females. 85.71% males and 14.29% females formed the Vision control group; on the other hand, 83.33% males and 16.67% females shaped the Vision experimental group.

The DOiT control group was formed of 75% (15) white/Caucasian, 20% (4) African American, and 5% (1) multiracial participants. The experimental group was formed by 80.95% (17) white/Caucasian, 14.29% (3) African American, and 4.76 % (1) multiracial participants (see Table 6.2).

Table 6.2 *Race and ethnicity data of the DOiT program control and experimental groups*.

DOiT			
Race/ethnicity	Control group	Treatment Group	Total
White/Caucasian	15	17	32
African American	4	3	7
Native American	-	-	-
Hispanic/Latino	-	-	-
Asian	-	-	-
Pacific Islander	-	-	-
Multiracial	1	1	2
Other	-	-	-
Total	20	21	41

In the Vision control group the participants identified themselves as white/Caucasian 9.52% (2), African American 38.1% (8), Hispanic/Latino 38.1% (8) and multiracial 14.29% (3). On the other hand, the experimental group was formed by 16% (3) white/Caucasian, 44.44% (8) African American and 38.89% (7) Hispanic/Latino.

Table 6.3 *Race and ethnicity data of the Vision program control and experimental groups*.

	Vision		
Race/ethnicity	Control group	Treatment Group	Total
White/Caucasian	2	3	5
African American	8	8	16
Native American	-	-	-
Hispanic/Latino	8	7	15
Asian	-	-	-
Pacific Islander	-	-	-
Multiracial	3	-	3
Other	-	-	-
Total	21	18	39

Figures 6.1 and 6.2 visually contrast the DOiT and Vision race and ethnicity data.

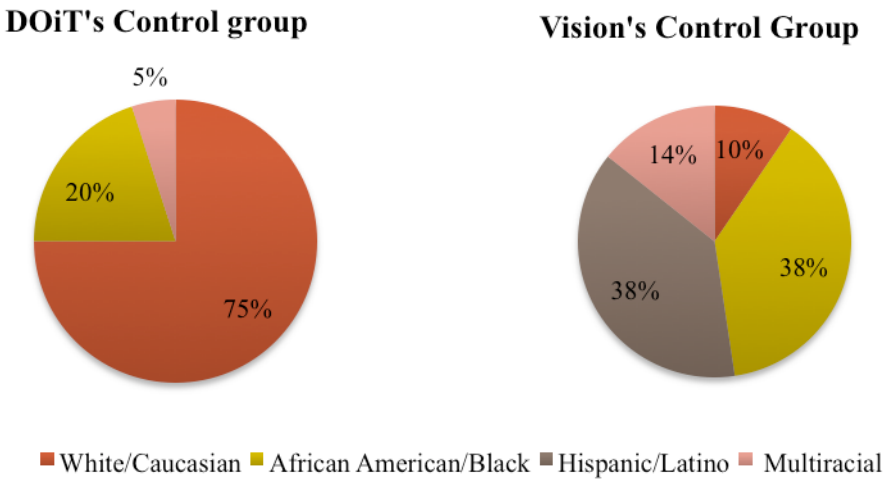

Figure 6.1 DOiT and Vision control group demographic information.

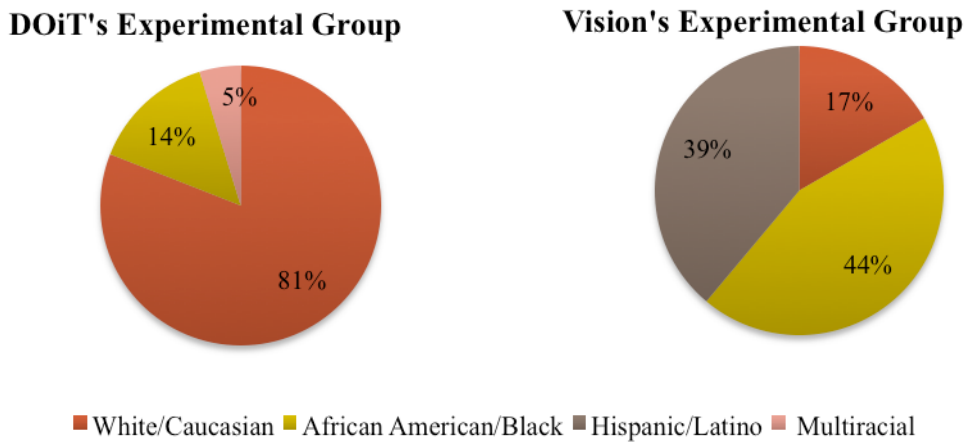

Figure 6.2 DOiT and Vision experimental group demographic information.

6.3 Background and Family Data

100% of the DOiT and Vision programs participants stated that they plan to attend college. Table 6.4 summarizes DOiT and Vision responses to the question "Do you have a role model who uses Information Technology in his/her career?" in the pre survey. 40%(8) of the DOiT's control group, 30%(6) of the Vision's control group, 33.3% (7) of the DOiT's experimental group and 15% (3) of the experimental group stated that they have a role model who uses IT in his/her career.

Table 6.4 *DOiT and Vision responses to question "Do you have a role model who uses Information Technology in his/her career?"*

	DOiT			Vision		
	Control	Experimental	Total	Control	Experimental	Total
No	6.3.1	5	8	13	7	11	18
Maybe	6.3.2	7	6	13	8	4	12
Yes	6.3.3	8	7	15	6	3	9

Table 6.5 summarizes the DOiT control group responses for question 10: What is the highest education level of your father?

Table 6.5 *DOiT control group and experimental group responses to question "What is the highest education level of your father?"*

	DOiT			
	Control		Experimental	
Option	Number of responses	%	Number of responses	%
Middle school or below	-	-	-	-
High school	5	25	7	33.3
Community college	2	10	2	9.5
Four year college	7	35	2	9.5
Masters level	4	20	7	33.3
Doctorate level	1	5	1	4.8
Other	1	5	2	9.5

The responses showed that 70% of DOiT's control group and 57.1% of the experimental group indicated that their fathers have some sort of higher education.

Figure 6.3 illustrates question 10 responses contrasted for both groups; the experimental group shows higher percentages of occurrence in "High School" and "Four year college". On the other hand the control group peak is on "Masters Level".

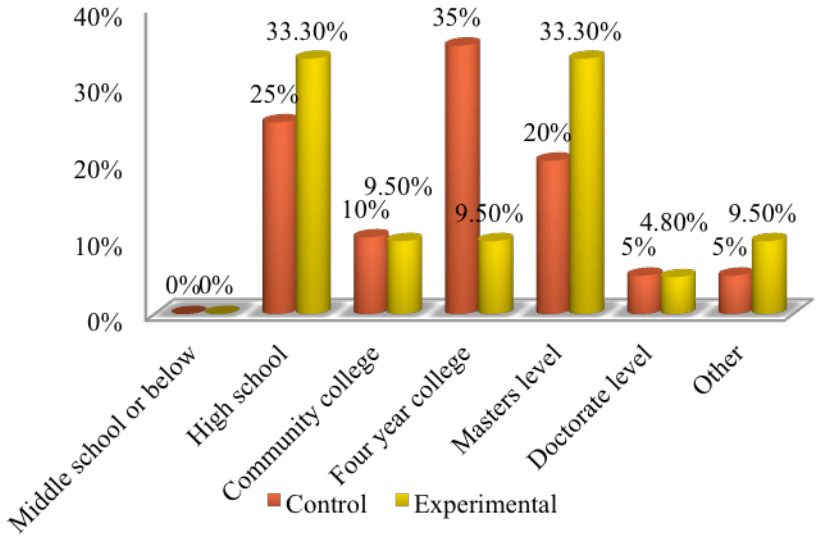

Figure 6.3 DOiT's control vs. experimental group question "What is the highest education level of your father?"

Table 6.6 summarizes Vision control group responses for question 10: What is the highest education level of your father?

Table 6.6 *Vision control group and experimental group responses to question "What is the highest education level of your father?"*

	Vision			
	Control		Experimental	
Option	Number of responses	%	Number of responses	%
Middle school or below	-	-	-	-
High school	7	33.3	6	33.3
Community college	3	14.3	2	11.1
Four year college	4	19.0	5	27.8
Masters level	5	23.8	3	16.7
Doctorate level	-	-	1	5.6
Other	2	9.5	1	5.6

The responses showed that 57.1% of the Vision's control group and 61.2% of the experimental group indicated that their fathers have some sort of higher education.

The largest amount of responses for the control group and experimental groups indicated "High School" as the higher level of education (see Figure 6.4).

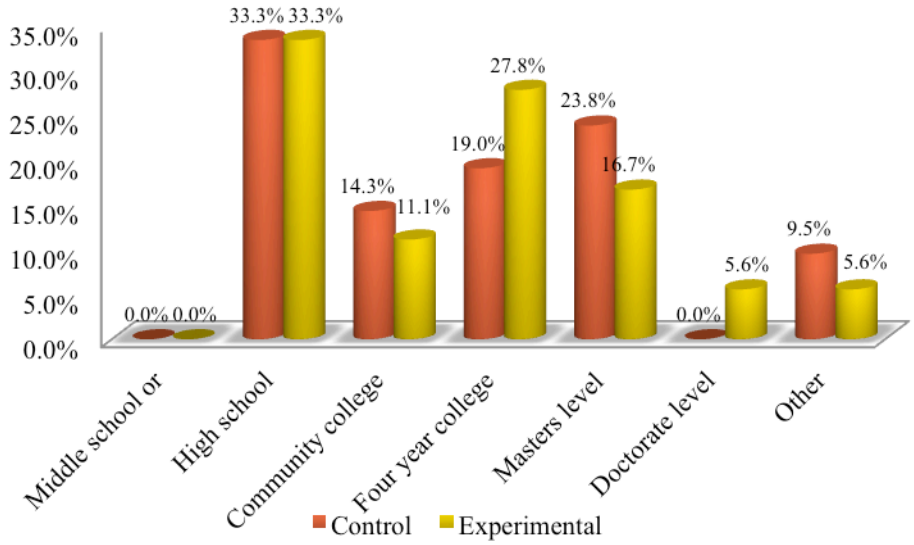

Figure 6.4 Vision's control vs. experimental group question "What is the highest education level of your father?"

Tables 6.7 and 6.8 summarize the DOiT control and experimental group responses to question 11: What is the highest education level of your mother?

Table 6.7 *DOiT control group responses to question "What is the highest education level of your mother?"*

	DOiT control group		
Option	Number of responses	%	Text response
Middle school or below	-	-	
High school	6	30	
Community college	3	15	
Four year college	6	30	
Masters level	4	20	
Doctorate level	-	-	
Other	1	5	"Bachelor's degree"

Table 6.8 *DOiT experimental group responses to question "*What is the highest education level of your mother?*"*

	DOiT experimental group		
Option	Number of responses	%	Text response
Middle school or below	1	4.8	
High school	2	9.5	
Community college	4	19.0	
Four year college	7	33.3	
Masters level	5	23.8	
Doctorate level	-	-	
Other	2	9.5	"some college"

70% of the DOiT control group participants specified that their mothers have some sort of higher education. On the other hand, the experimental group indicated a 76.2%.

Figure 6.5 contrasts the data from the control group and experimental group. The control group shows higher percentages of occurrence in "High School" and "Four year college". On the other hand the experimental group peak is on "Four year college".

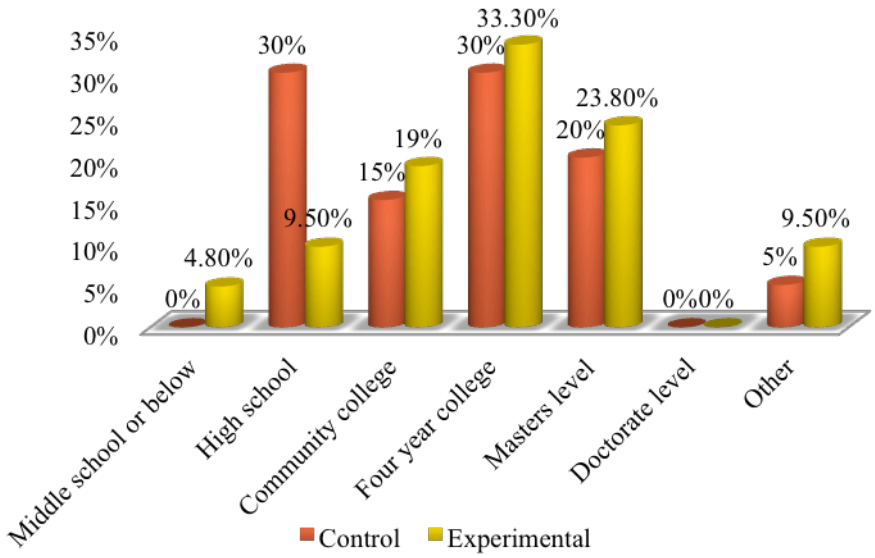

Figure 6.5 DOiT's control vs. experimental group question "What is the highest education level of your mother?"

Tables 6.9 and 6.10 summarize the Vision control group and experimental group responses to question 11: What is the highest education level of your mother?

Table 6.9 *Vision control group responses to question "What is the highest education level of your mother?"*

	Vision control group		
Option	Number of responses	%	Text response
Middle school or below	-	-	
High school	4	19.0	
Community college	2	9.5	
Four year college	9	42.9	
Masters level	4	19.0	
Doctorate level	1	4.8	
Other	1	4.8	"In college"

Table 6.10 *Vision experimental group responses to question "What is the highest education level of your mother?"*

	Vision experimental group		
Option	Number of responses	%	Text response
Middle school or below	-	-	
High school	6	33.3	
Community college	1	5.6	
Four year college	6	33.3	
Masters level	4	22.2	
Doctorate level	-	-	
Other	1	5.6	"Currently enrolled in a PHD Program"

Figure 6.6 contrasts the data from the control group and experimental group. The control group shows higher percentages of occurrence in "Four year college". On the other hand the experimental group peak is on "High School" along with "Four year college".

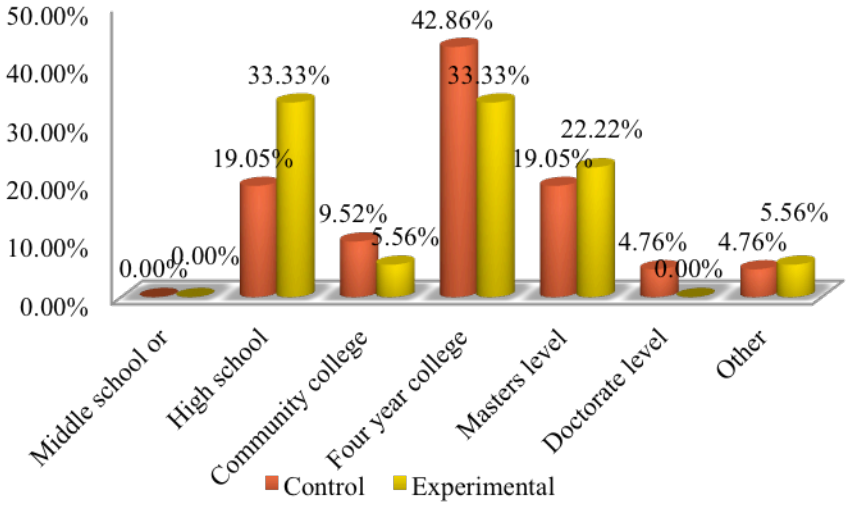

Figure 6.6 Vision's control vs. experimental group question "What is the highest education level of your mother?"

6.4 Variables Statistical Analysis

To compare data between control group and experimental group the researcher used a two-sample t-test. To process pre and post interest the researcher used a paired t-test. The correlation between inters and self-beliefs were carried out using correlational statistics to obtain a correlation coefficient. A confidence level of 95% (α=0.05) was applied to all statistical tests.

6.4.1 Interest Pre-survey Control Group vs. Experimental Group

In order to determine if the level of interest was statistically equal at the beginning of the intervention a two-sample t-test was conducted to the overall interest of the pre-test control group vs. experimental group for both camps.

The following hypotheses were tested:

H_0: $\mu_{control}-\mu_{experimental}=0$, there is no significant difference between the control group and experimental group.

H_{a1}: $\mu_{control}-\mu_{experimental}<0$, there is an increment in the means from the experimental group.

H_{a2}: $\mu_{control}-\mu_{experimental}>0$, there is an increment in the means from the experimental group.

Ho can be rejected only if the P-value is less or equal to α (0.05). The P-value is defined by Devore (2012) as the following: "The probability, calculated assuming that the null hypothesis is true, of obtaining a value of the test statistic at least as contradictory to Ho as the value calculates from the available sample" (p. 329). Table 6.11 shows the statistical data obtained from the t-test, H_0 cannot be rejected for DOiT or Vision. In other words, the level of interest is statistically equal at the beginning of the sessions for both programs.

Table 6.11 *Statistical analysis for DOiT and Vision pre-survey control vs. experimental group.*

	DOiT	Vision
t	0.7799	0.2928
df	36.905	38.54
P-value H_{a1}	0.2202	0.3856
P-value H_{a2}	0.7798	0.6144

t = test statistical value, df = degrees of freedom, *p≤0.05.

6.4.2 Interest and Intent's Pre vs. Post Survey

The investigator used a paired t-test for the statistical analysis of the 4 interest and 2 intent questions that appear in the pre and post surveys. This analysis focuses in the

interest variable and in its behavior before and after the session. The paired t-test will test the following hypotheses for each question:

H_o: μ_{pre}-μ_{post}=0, there is no significant difference between pre and post session data.

H_a: μ_{pre}-μ_{post}<0, there is an increment in the means from the post survey.

H_o can be rejected only if the P-value is less or equal to α (0.05).

6.4.2.1 Interest Questions

The following table shows the data collected for the question 1: "I'm familiar with Information Technology"

50% of the DOiT control group and 38.09% of the experimental group participants agreed or strongly agreed with this statement. After, the session these percentages changed to 90% for the control group and 80.95% for the experimental group. An increment of 40% and 42.86%, respectively, was observed (see Table 6.12 and Figures 6.7 and 6.8).

Table 6.12 *DOiT control group and experimental group responses to "I'm familiar with Information Technology" of pre and post surveys.*

	6.4.2.1.1 DOiT			
	Control		Experimental	
	Pre- survey	Post - survey	Pre- survey	Post - survey
Strongly Disagree	3	-	3	-
Disagree	3	-	4	-
Neither Agree nor Disagree	4	2	6	4
Agree	10	10	6	13
Strongly Agree	-	8	2	4

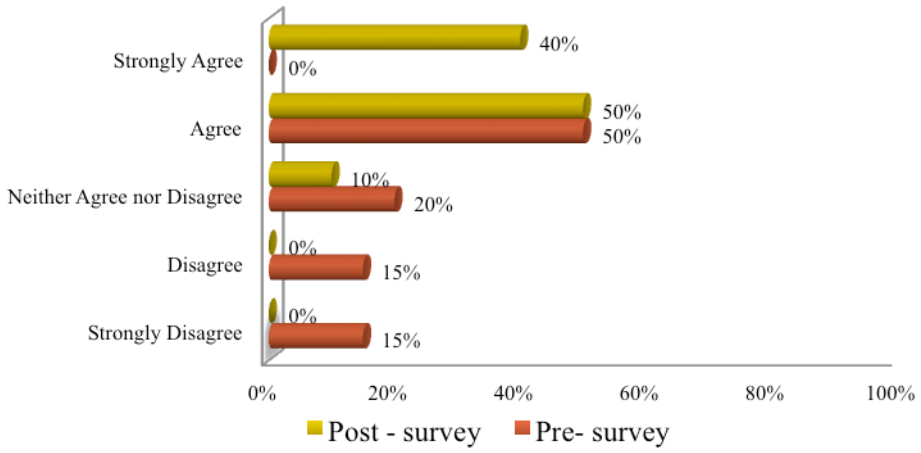

Figure 6.7 DOiT control group responses to question "I'm familiar with Information Technology" of pre and post surveys.

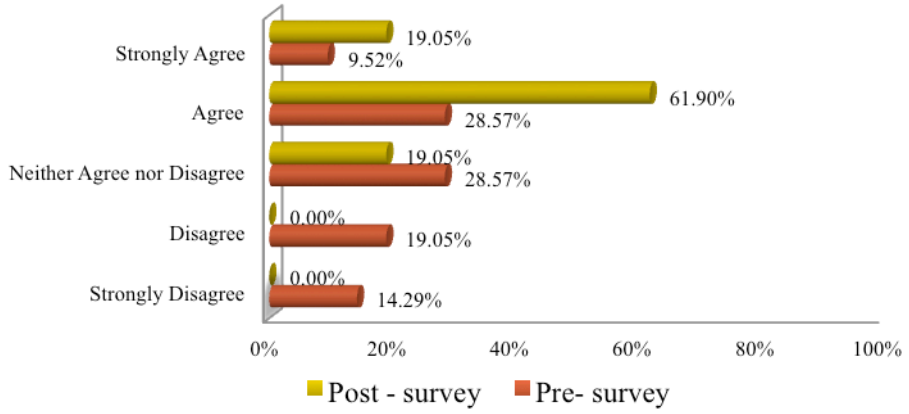

Figure 6.8 DOiT experimental group responses to question "I'm familiar with Information Technology" of pre and post surveys.

47.62% of the Vision control group and 50% of the experimental group participants agreed or strongly agreed with this statement. After, the session these percentages changed to 85.71% for the control group and 77.78% for the experimental group. An increment of 38.09% and 27.78%, respectively, was observed (see Table 6.13 and Figures 6.9,6.10).

Table 6.13 *Vision control group and experimental group responses to question "I'm familiar with Information Technology" of pre and post surveys.*

	Vision			
	Control		Experimental	
	Pre- survey	Post - survey	Pre- survey	Post - survey
Strongly Disagree	2	2	1	-
Disagree	4	-	5	2
Neither Agree nor Disagree	5	1	3	2
Agree	7	14	8	10
Strongly Agree	3	4	1	4

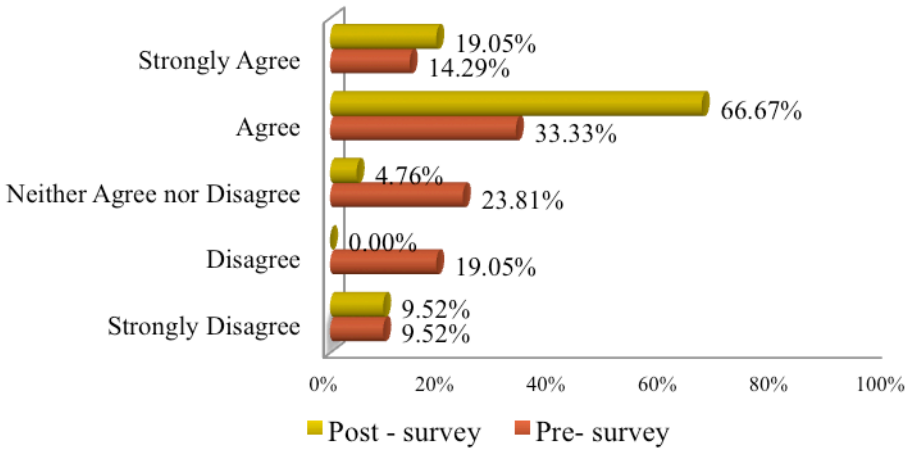

Figure 6.9 DOiT control group responses to question "I'm familiar with Information Technology" of pre and post surveys.

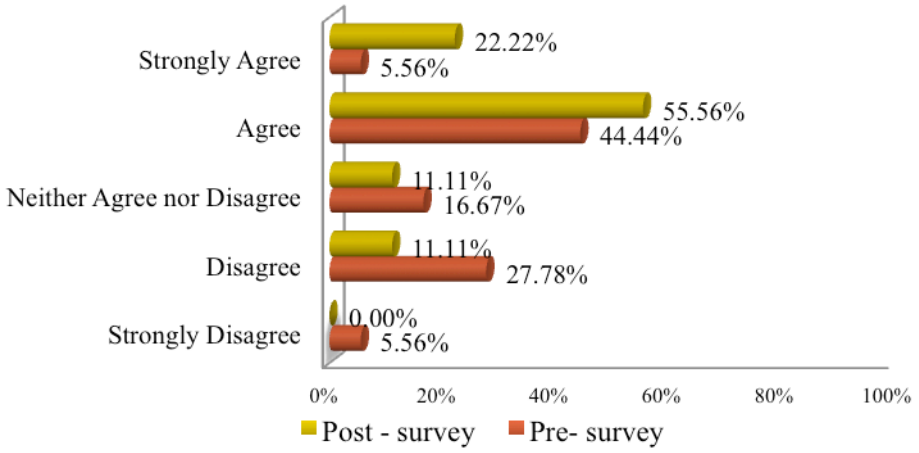

Figure 6.10 Vision experimental group responses to question "I'm familiar with Information Technology" of pre and post surveys.

The paired t-test performed in this question indicates, based on the P-value, that the session had a positive impact in the participants of DOiT and Vision. Table 6.14 summarizes statistical data obtained from the paired t-test.

Table 6.14 *Statistics, DOiT and Vision control group and experimental group question "I'm familiar with Information Technology"* .

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Min Value	1	3	1	3	1	1	1	2
Max Value	4	5	5	5	5	5	5	5
Mean	3.05	4.3	3	4	3.24	3.86	3.17	3.89
t	-5.483		-4.5826		-2.2804		-2.7176	
df	19		20		20		17	
P-value	1.37E-05*		9.03E-05*		0.01684*		0.00731*	

t = test statistical value, df = degrees of freedom, *p≤0.05.

The following table (Table 6.15) shows the data collected for the question 2: "I'm interested in careers from the Information Technology field"

Table 6.15 *DOiT and Vision control group and experimental group responses to question "I'm interested in careers from the Information Technology field" of pre and post surveys.*

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Strongly Disagree	1	-	-	-	1	1	-	1
Disagree	1	1	-	-	4	1	2	4
Neither Agree nor Disagree	5	3	10	6	6	3	4	3
Agree	11	9	9	11	7	9	11	8
Strongly Agree	2	7	2	4	3	7	1	2

The responses in the pre survey show that 65% of the DOiT control group and 52.38% of the experimental agreed or strongly agreed with the statement. After the session these percentages incremented 15% (total 80%) for the control group and 19.05% (total 71.43%) for the experimental group (see Figures 6.11 and 6.12).

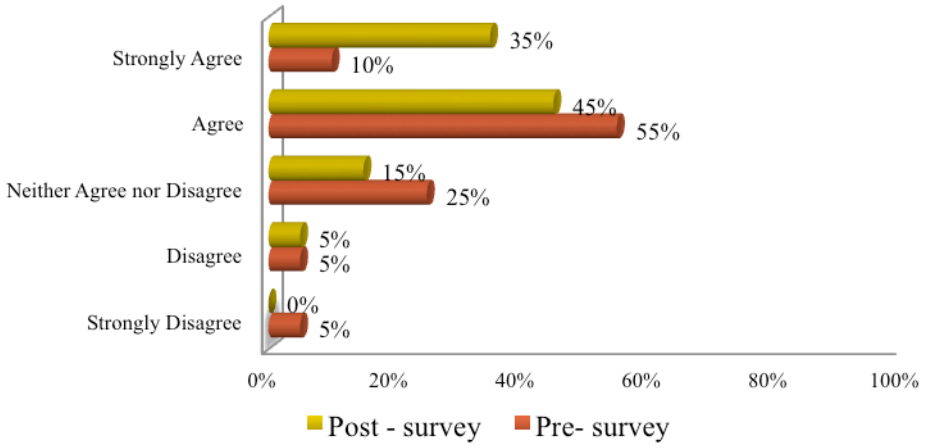

Figure 6.11 DOiT control group responses to question "I'm interested in careers from the Information Technology field" of pre and post surveys.

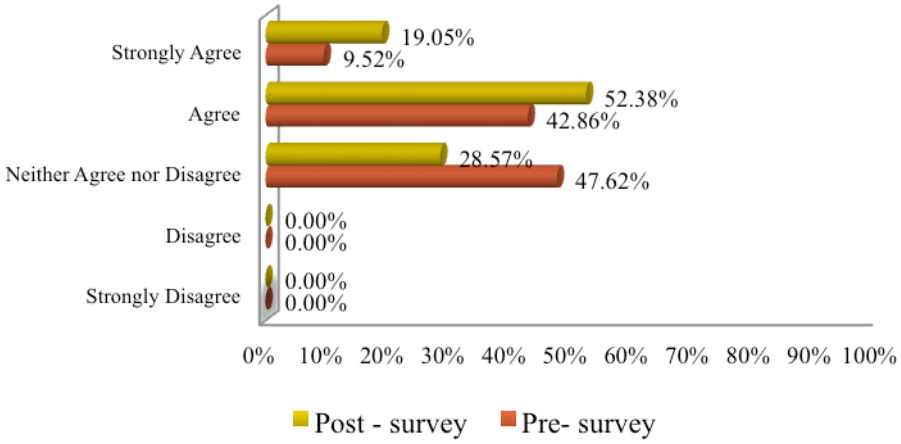

Figure 6.12 DOiT experimental group responses to question "I'm interested in careers from the Information Technology field" of pre and post surveys.

On the other hand, the responses that agreed or strongly agreed with the statement for Vision program increased from 47.62% to 76.19% for the control group and decreased from 66.67% to 55.56% on the experimental group (see Figures 6.13 and 6.14).

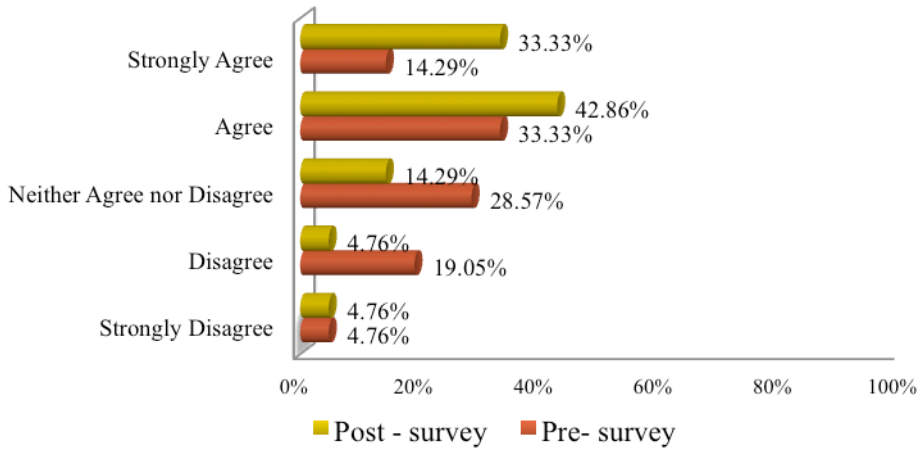

Figure 6.13 Vision control group responses to question "I'm interested in careers from the Information Technology field" of pre and post surveys.

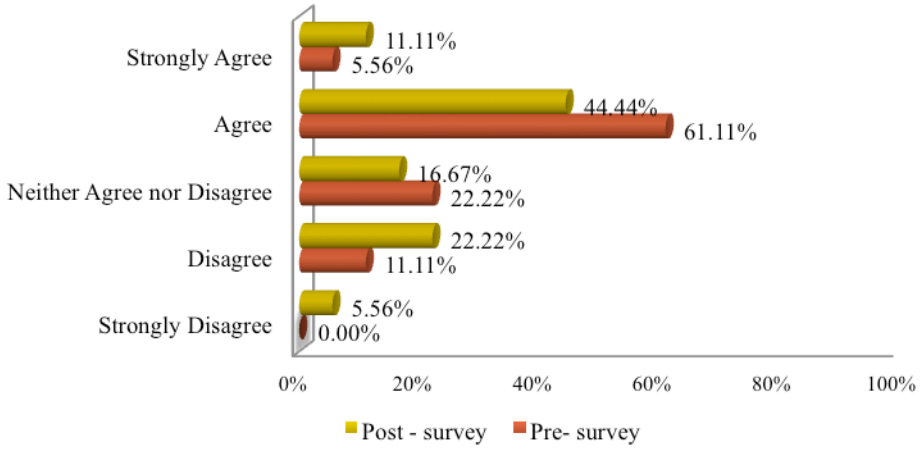

Figure 6.14 Vision experimental group responses to question "I'm interested in careers from the Information Technology field" of pre and post surveys.

The paired t-test performed in this question indicates, based on the P-value, that the session had a positive impact in the participants from DOiT's control and experimental group, and on the Vision control group. However, the experimental group of Vision did not register a sufficient boost on the mean to be significant. Table 6.16

summarizes statistical data obtained from the paired t-test. Statement that agrees with the perceptual increase previously observed in the DOiT and the slight decreased on Vision.

Table 6.16 *Statistics, DOiT and Vision control group and experimental group question "I'm interested in careers from the Information Technology field"*

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Min Value	1	2	3	3	1	1	2	1
Max Value	5	5	5	5	5	5	5	5
Mean	3.6	4.1	3.6	3.9	3.33	3.95	3.61	3.33
t	-1.6967		-2.8284		-1.8922		0.893	
df	19		20		20		17	
P-value	0.05304		0.005191*		0.03651*		0.8078	

t = test statistical value, df = degrees of freedom, *p≤0.05.

Table 6.17 shows the data collected for the question 3: "I use Information Technology daily"

Table 6.17 *DOiT and Vision control group and experimental group responses to question "I use Information Technology daily" of pre and post surveys.*

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Strongly Disagree	1	-	-	-	1	2	-	-
Disagree	-	-	2	-	1	3	-	1
Neither Agree nor Disagree	5	2	6	4	6	4	6	2
Agree	12	10	7	8	11	5	9	5
Strongly Agree	2	8	6	9	2	7	3	10

The data collected from the DOiT session shows that 70% of the control group and 61.95% of the experimental group participants agreed or strongly agreed with this statement in the pre-survey. After the session 90% of the control group and 80.96% of the experimental group agreed or strongly agreed, an increment of 20% and 19.06%, correspondingly (See Figures 6.14 and 6.15).

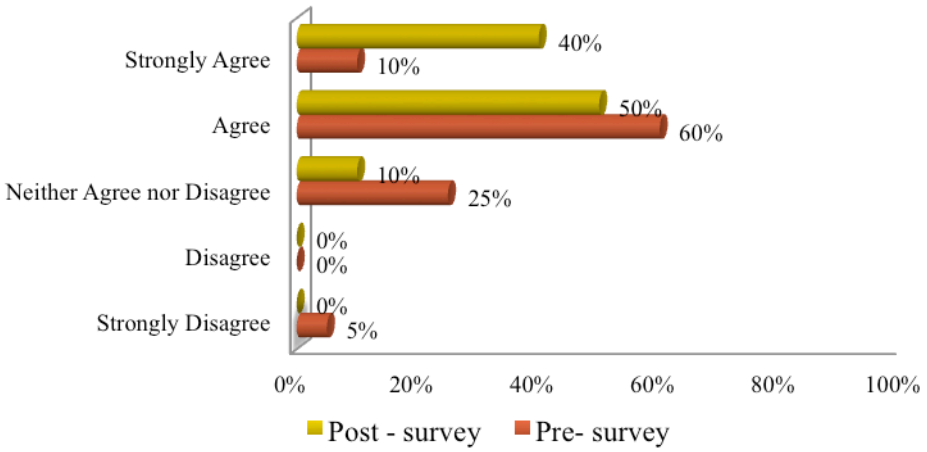

Figure 6.15 DOiT control group responses to question "I use Information Technology daily" of pre and post surveys.

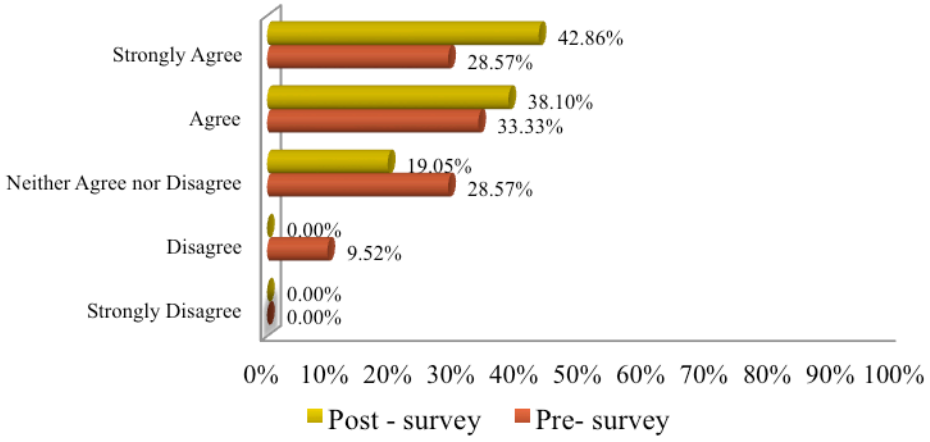

Figure 6.16 DOiT experimental group responses to question "I use Information Technology daily" of pre and post surveys.

The data collected from Vision program shows that 61.90% of the control group and 66.67% of the experimental group participants agreed or strongly agreed with this statement in the pre-survey. After the session 57.14% of the control group and 83.33% of the experimental group agreed or strongly agreed (See Figures 6.16 and 6.17).

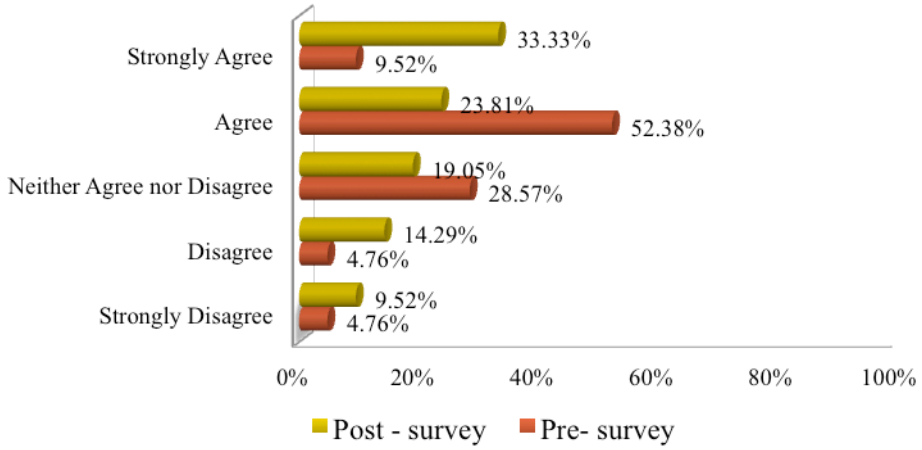

Figure 6.17 Vision control group responses to question "I use Information Technology daily" of pre and post surveys.

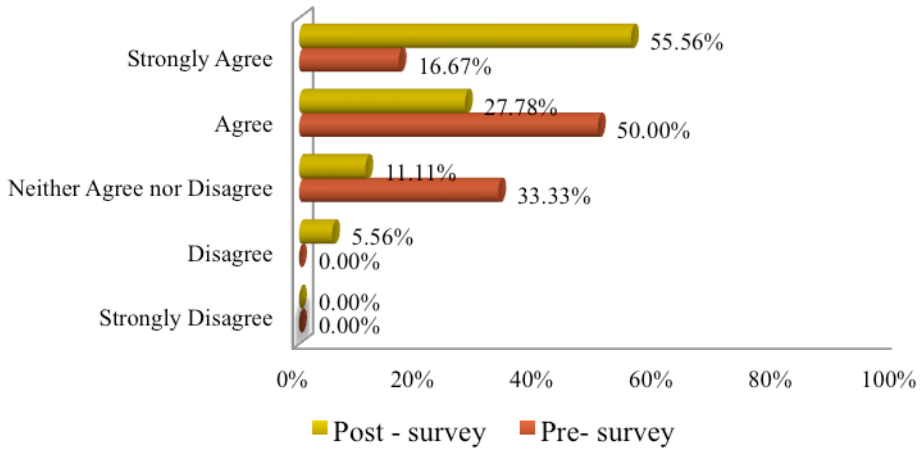

Figure 6.18 Vision experimental group responses to question "I use Information Technology daily" of pre and post surveys.

The paired t-test performed in this question data indicates, based on the p-value, showed that the session had a positive impact in the participants from both groups at DOiT and for the experimental group of the Vision. However, the Vision's control group did not present a change in the amount of interest for this question. Table 6.18 summarizes statistical data obtained from the paired t-test. Statement that agrees with the perceptual increase observed.

Table 6.18 *Statistics, DOiT and Vision control group and experimental group question* "I use Information Technology daily".

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Min Value	1	3	2	3	1	1	3	2
Max Value	5	5	5	5	5	5	5	5
Mean	3.7	4.3	3.8	4.2	3.57	3.57	3.83	4.33
t	-2.5646		-1.8257		0		-1.9318	
df	19		20		20		17	
p-value	0.009482*		0.04143*		0.5		0.03512*	

t = test statistical value, df = degrees of freedom, *p≤0.05.

The following table shows the data collected for the question 4: “I think Information Technology is interesting”

Table 6.19 *DOiT and Vision control and experimental group responses to question* “I think Information Technology is interesting” *of pre and post surveys.*

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Strongly Disagree	1	-	-	-	1	1	-	-
Disagree	-	-	-	-	-	1	1	2
Neither Agree nor Disagree	4	-	4	3	9	2	4	-
Agree	11	10	12	13	8	9	10	9
Strongly Agree	4	10	5	5	3	8	3	7

The responses collected in the DOiT session indicated that 75% of the control group and 80.95% of the experimental group participants agreed or strongly agreed with the statement in the pre-survey. After the session a 100% of the control group and 85.71% of the experimental group agreed or strongly agreed with the statement, an increment of 25% and 4.76% respectively (See Figure 6.18 and 6.19).

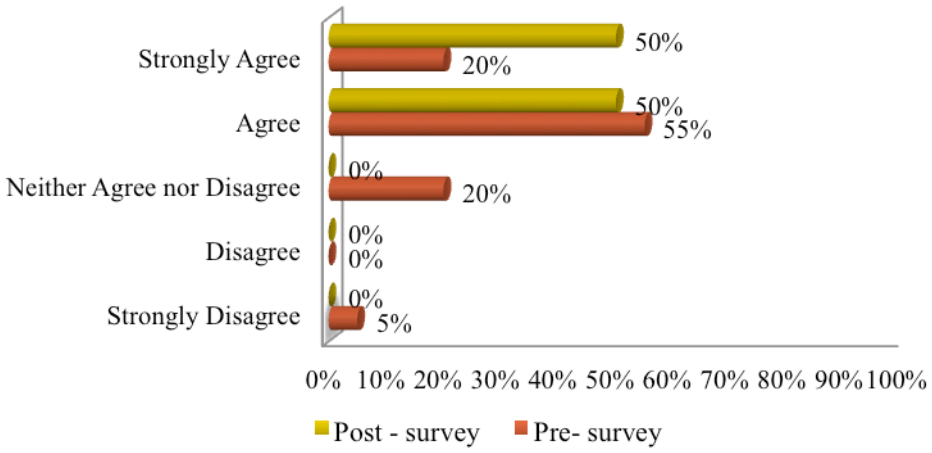

Figure 6.19 DOiT control group responses to question "I think Information Technology is interesting" of pre and post surveys.

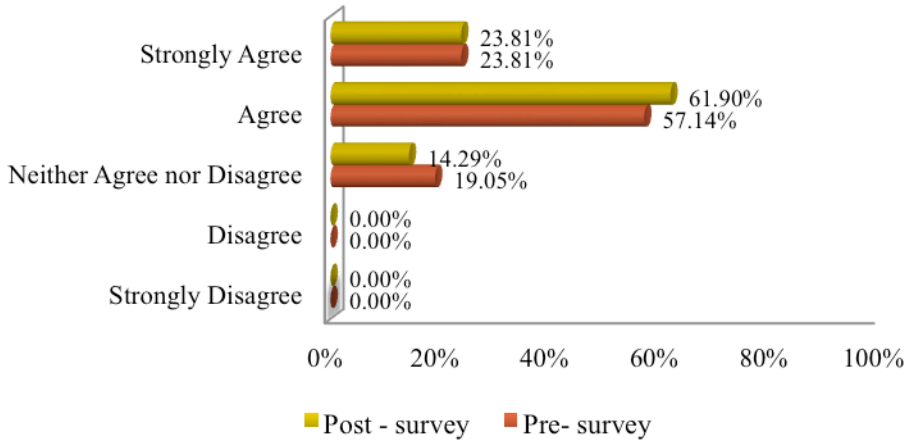

Figure 6.20 DOiT experimental group responses to question "I think Information Technology is interesting" of pre and post surveys.

The responses collected in the Vision program indicated that 52.38% of the control group and 72.22% of the experimental group participants agreed or strongly agreed with the statement in the pre-survey. After the session 80.95% of the control group and 88.89% of the experimental group agreed or strongly agreed with the statement (See Figure 6.20 and 6.21).

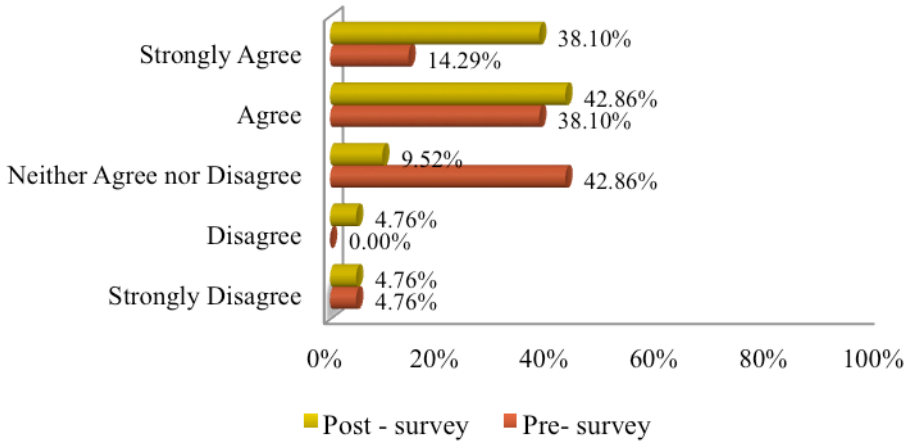

Figure 6.21 Vision control group responses to question "I think Information Technology is interesting" of pre and post surveys.

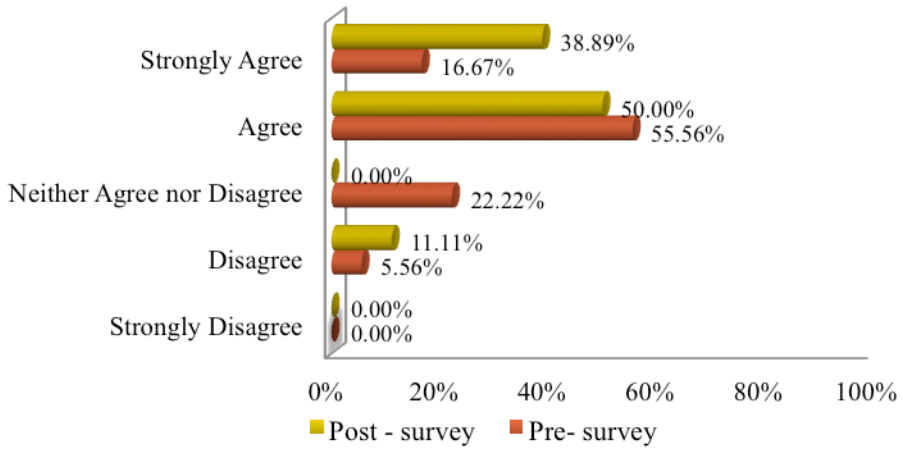

Figure 6.22 Vision experimental group responses to question "I think Information Technology is interesting" of pre and post surveys.

The paired t-test performed in this question data indicates, based on the p-value, that the control session had a positive impact in both programs. While in the Vision and DOiT experimental groups the session had a positive impact however it was not enough

to create a statistical difference between the pre-survey and the post-survey responses. Table 6.20 summarizes statistical data obtained from the paired t-test.

Table 6.20 *Statistics, DOiT and Vision control group and experimental group question* "I think Information Technology is interesting"

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Min Value	1	4	3	3	1	1	2	2
Max Value	5	5	5	5	5	5	5	5
Mean	3.85	4.5	4	4.1	3.57	4.05	3.83	4.17
t	-2.9419		-0.3262		-2.9111		-1.1902	
df	19		20		20		17	
P-value	0.004185*		0.3738		0.004318*		0.125	

t = test statistical value, df = degrees of freedom, *p≤0.05.

In order to determine if the overall interest increased a paired t-rest was conducted using the means of the four interest questions (Table 6.21). The results indicate an increase on both DOiT groups and Vision's control group. However, the mean increase on the Vision's experimental group was not enough to show a statistical difference.

Table 6.21 Interest *P-value results for DOiT and Vision programs.*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
P-value	0.0006405*	0.0006041*	0.005843*	0.06512

*p≤0.05

6.4.2.2 Intent Questions

Table 6.22 displays the data collected for the question 7 in the pre-survey and 18 on the post-survey: "Do you plan to pursue an Information Technology career?"

Table 6.22 *DOiT and Vision control group and experimental group responses to question* "Do you plan to pursue an Information Technology career?" *of pre and post surveys*

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
No	1	1	4	5	8	5	3	5
Maybe	17	17	11	12	13	14	15	8
Yes	2	2	6	4	0	2	0	5

This question evaluates the intent of the participants to pursue IT careers. The DOiT data for the control group pre-survey showed that 85% of participants will follow or may follow an IT career; this proportion did not change after the session (Figure 6.23). On the other hand, the experimental group pre-survey data showed an 80.95% of participants will or may follow an IT career, the intent percentage diminished to a 76.15% after the session (Figure 6.24).

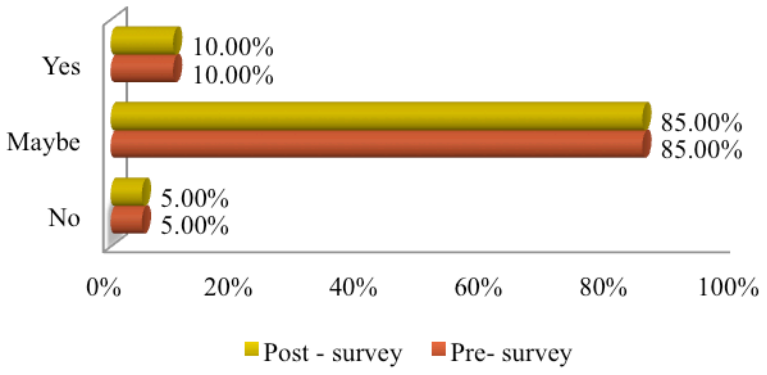

Figure 6.23 DOiT control group responses to question "Do you plan to pursue an Information Technology career?"

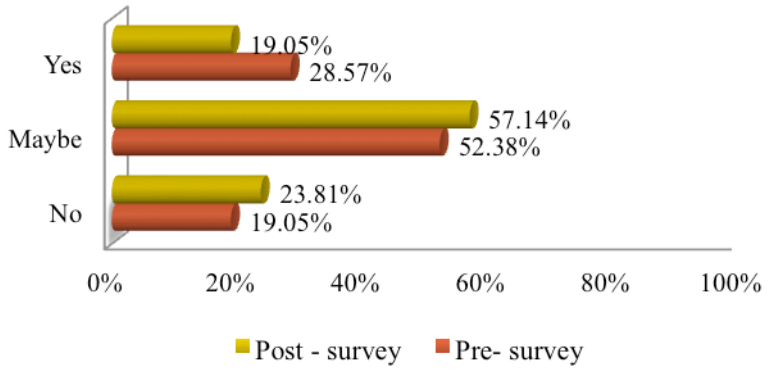

Figure 6.24 DOiT experimental group responses to question "Do you plan to pursue an Information Technology career?"

The Vision data for the control group pre-survey showed that 61.90% of participants will follow or may follow an IT career, this percentage increased to 76.19% after the session (Figure 6.25). On the other hand, the experimental group pre-survey data showed an 83.33% of participants will or may follow an IT career, this percentage decrease to a 72.22% after the session (Figure 6.26).

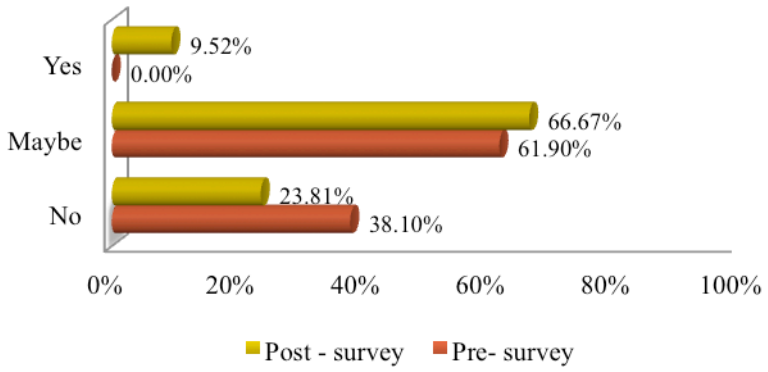

Figure 6.25 Vision experimental group responses to question "Do you plan to pursue an Information Technology career?"

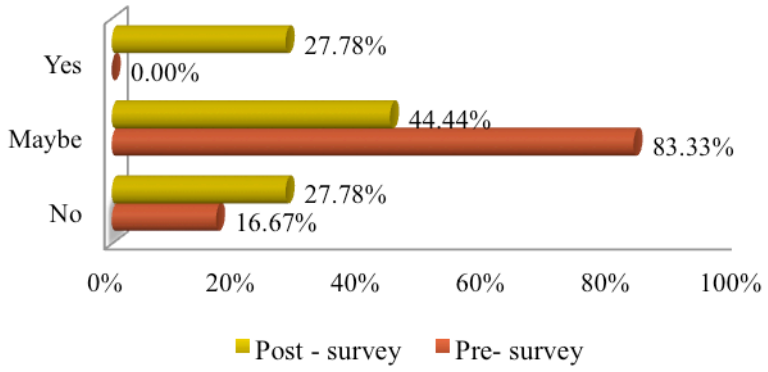

Figure 6.26 Vision experimental group responses to question "Do you plan to pursue an Information Technology career?"

The paired t-test results (Table 6.23) indicated that there is not enough statistical evidence to reject the H_o, in other words the session did not influence the DOiT participants' intent to pursue IT careers and on the Vision experimental group. On the other hand, the Vision control group presented an increase in their intent to pursue IT careers.

Table 6.23 *Statistics, DOiT and Vision control group and experimental group question* "Do you plan to pursue an Information Technology career?"

	6.4.2.2.1 DOiT				6.4.2.2.2 Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Min Value	1	1	1	1	1	1	1	1
Max Value	3	3	3	3	2	3	2	3
Mean	2.05	2.05	2.1	1.95	1.62	1.86	1.83	2
t	0		1.8257		-2.0244		-1	
df	19		20		20		17	
P-value	0.5		0.9586		0.02824*		0.1657	

t = test statistical value, df = degrees of freedom, *p≤0.05.

The following table shows the data collected for the question: "Do you plan to pursue a technology related career?" this question was 8th on the pre-survey and 19th on the post-survey.

Table 6.24 *DOiT and Vision control group and experimental group responses to question* "Do you plan to pursue a technology related career?"

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
No	1	1	3	1	3	2	0	1
Maybe	14	3	9	8	7	8	6	5
Yes	5	16	9	12	11	11	12	12

This question was meant to evaluate if the session had any impact on the participants intent to pursue a technology related career. The responses collected from the DOiT's control group indicated that 95% of the participants will or may pursue a technology related career; this proportion did not change after the outreach session (Figure 6.27). However, there was a remarkable increment on the positivisms to pursue technology, which went from 25% to 80% after the session.

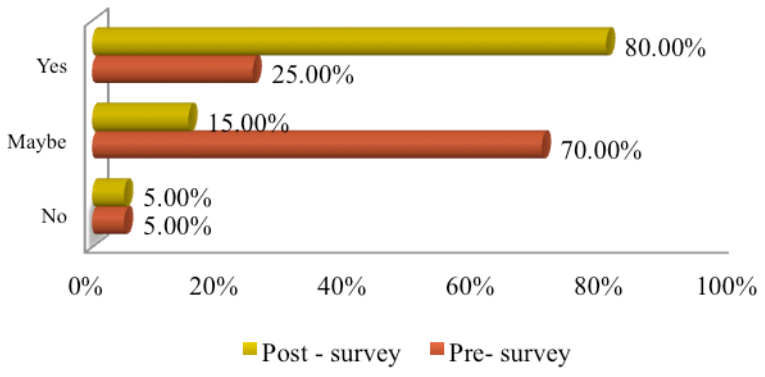

Figure 6.27 DOiT control group responses to question "Do you plan to pursue a technology related career?"

On the other hand, the DOiT's experimental group data indicates that the intent went from 85.72% to a 95.24% (Figure 6.28).

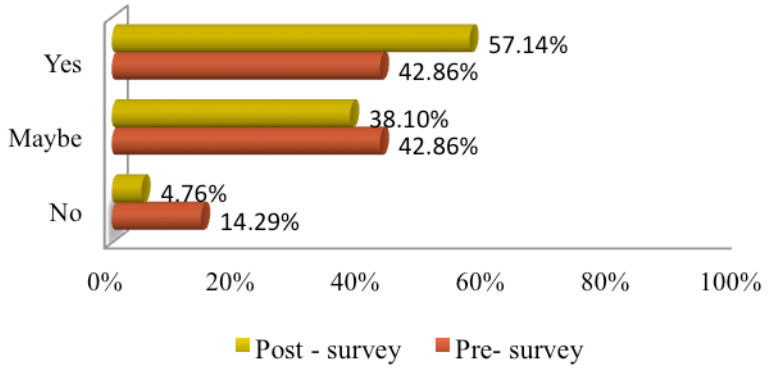

Figure 6.28 DOiT experimental group responses to question "Do you plan to pursue a technology related career?"

The responses collected from the Vision's control group indicated that 85.71% of the participants will or may pursue a technology related career. After the session the control group percentage increased to 90.48% (Figure 6.29).

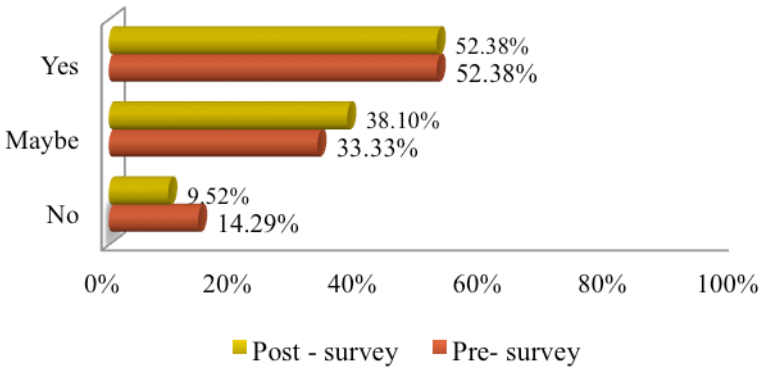

Figure 6.29 Vision control group responses to question "Do you plan to pursue a technology related career?"

On the other hand, the responses collected from the Vision's experimental group decreased from 100% to a 94.44% after the session the control group percentage increased to 90.48% (Figure 6.30).

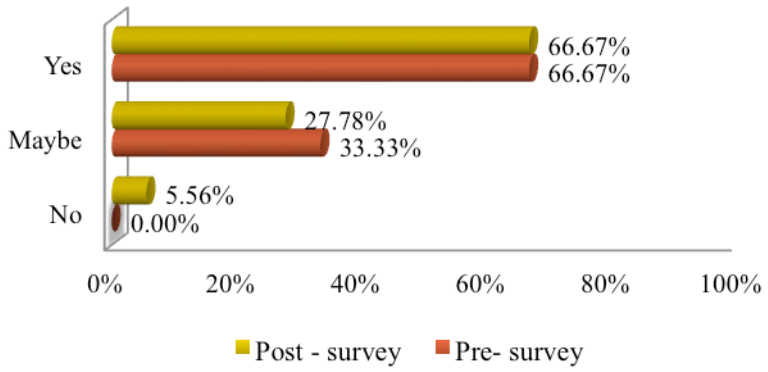

Figure 6.30 Vision experimental group responses to question "Do you plan to pursue a technology related career?"

The paired t-test performed on the control and experimental groups' pre and post surveys indicated that there was an increment in the intent to pursue a technology career for the DOiT's control group participants. However, the session did not influence the DOiT experimental group or both Vision groups in the intent to pursue technology careers (Table 6.25).

Table 6.25 *Statistics, DOiT control group and experimental group question "Do you plan to pursue a technology related career?"*

	DOiT				Vision			
	Control		Experimental		Control		Experimental	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Min Value	1	1	1	1	1	1	2	1
Max Value	3	3	3	3	3	3	3	3
Mean	2.2	2.75	2.29	2.52	2.38	2.45	2.67	2.61
t	-3.5838		-1.2272		0.3701		0.2701	
df	19		20		20		17	
P-value	0.0009901*		0.117		0.3576		0.6048	

t = test statistical value, df = degrees of freedom, *p≤0.05.

6.4.3 Post-survey Control vs. Treatment Groups

The investigator used a two-sample t-test for the statistical analysis of the four (4) interest, two (2) intent, and four (4) session feedback questions that appear in the post-survey. The two-sample t-test will test the following hypotheses for each question:

H_o: $\mu_{control}-\mu_{experimental}=0$, there is no significant difference between the control group and experimental group.

H_a: $\mu_{control}-\mu_{experimental}<0$, there is an increment in the means from the experimental group.

H_o can be rejected only if the P-value is less or equal to α (0.05).

6.4.3.1 Interest Questions

Table 6.26 summarizes statistical data obtained with the two-sample test for DOIT's question 1: "I'm familiar with Information Technology", the P-value is greater than the $\alpha(0.05)$, which translates in that there is not a significant difference between the two treatments for any of the progrms.

Table 6.26 *Two-sample t-test data for DOiT and Vision of question "I'm familiar with Information Technology"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.34	4	3.86	3.89
t	1.5916		-0.101	
df	36.505		36.998	
P-value	0.9399		0.46	

t = test statistical value, df = degrees of freedom, *p≤0.05.

Table 6.27 summarizes statistical data obtained for DOiT's question 2: "I'm interested in careers from the Information Technology field", based on the P-value obtained there is not a significant difference between the two treatments neither for DOiT or Vision.

Table 6.27 *Two-sample t-test data for DOiT and Vision of question "I'm interested in careers from the Information Technology field"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.1	3.9	3.95	3.33
t	0.7992		1.7402	
df	36.827		35.32	
P-value	0.7854		0.9547	

t = test statistical value, df = degrees of freedom, *$p \leq 0.05$.

The following table (Table 6.28) summarizes statistical data obtained for DOIT's question 3: "I use Information Technology daily" the P-value obtained with the two-sample t-test indicates that there is not a significant difference between the two treatments on DOiT. On the other hand, the Vision program experimental group presented a statistical difference; the treatment had a greater positive impact in the participants of the experimental group compared to the control group.

Table 6.28 *Two-sample t-test data for DOiT and Vision of question "I use Information Technology daily"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.3	4.23	3.57	4.33
t	0.2777		-2.0799	
df	38.567		35.02	
P-value	0.6086		0.02246*	

t = test statistical value, df = degrees of freedom, *p≤0.05.

Table 6.29 summarizes statistical data obtained for DOiT's question 4: "I think Information Technology is interesting" the statistical data obtained implies that there is not a significant difference between the two treatments neither on DOiT or Vision.

Table 6.29 *Two-sample t-test data for DOiT and Vision of question "I think Information Technology is interesting"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.5	4.1	4.05	4.17
t	2.2715		-0.3727	
df	38.19		36.996	
P-value	0.9856		0.3558	

t = test statistical value, df = degrees of freedom, *p≤0.05.

In order to determine if the overall interest increased a two-sample t-rest was conducted using the means of the four interest questions (Table 6.30). The P-value

indicates that there is not enough statistical evidence to reject *Ho,* in other words booth sessions have similar impact on the participants interest.

Table 6.30 Interest *P-value results for DOiT and Vision programs.*

	DOiT	Vision
	Control vs. Experimental	Control vs. Experimental
P-value	0.9425	0.392

*p≤0.05

6.4.3.2 Intent Questions

Table 6.31 condenses statistical data obtained for DOiT's question 5: "I plan to use technology in my future career" the statistical data obtained implies that there is not a significant difference between the two treatments neither for DOiT nor Vision.

Table 6.31 *Two-sample t-test data for DOiT question "I plan to use technology in my future career"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.05	4.1	4.19	3.89
t	-0.1672		0.8773	
df	33.901		36.847	
P-value	0.4341		0.807	

t = test statistical value, df = degrees of freedom, *p≤0.05.

The following table (Table 6.32) summarizes statistical data obtained for DOiT's question 6: "If I study Information Technology in college, I will be able to pursue many

different types of careers", the P-value obtained indicates that there is not a significant difference between the two treatments neither for DOiT nor Vision.

Table 6.32 *Two-sample t-test data for DOiT and Vision of question "If I study Information Technology in college, I will be able to pursue many different types of careers"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.3	4.28	4	4.17
t	0.0498		-0.4897	
df	35.463		36.994	
P-value	0.5197		0.3136	

t = test statistical value, df = degrees of freedom, *p≤0.05.

6.4.3.3 Feedback Questions

Table 6.33 summarizes statistical data obtained for DOiT question 14: "This session was informative". The statistical data shows that there is not a significant difference between the two treatments neither for DOiT nor Vision.

Table 6.33 *Two-sample t-test data for DOiT and Vision question "This session was informative"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.25	4.14	3.95	4.11
t	0.412		-0.4393	
df	29.612		35.94	
P-value	0.6584		0.3316	

t = test statistical value, df = degrees of freedom, *p≤0.05.

The following table (Table 6.34) summarizes statistical data obtained for DOiT's question 15: "This session was fun", the P-value indicated that there is not a significant difference between the two treatments neither for DOiT nor Vision.

Table 6.34 *Two-sample t-test data for DOiT and Vision question "This session was fun"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.2	3.9	3.95	4.11
t	1.0936		-0.5376	
df	38.415		34.571	
p-value	0.8595		0.2971	

t = test statistical value, df = degrees of freedom, *p≤0.05.

Table 6.35 summarizes statistical data obtained for DOiT's question 16: "This experience incremented my interest in Information Technology", the P-value shows that there is not a significant difference between the two treatments neither for DOiT nor Vision.

Table 6.35 *Two-sample t-test data for DOiT and Vision question "This experience incremented my interest in Information Technology"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.05	3.52	3.43	3.83
t	1.6967		-1.2832	
df	37.877		36.014	
p-value	0.951		0.1038	

t = test statistical value, df = degrees of freedom, *p≤0.05.

Table 6.36 summarizes statistical data obtained for DOiT's question17: "Today's session impacted positively on my intentions of pursuing an Information Technology major in college", the data indicates that there is not a significant difference between the two treatments neither for DOiT nor Vision.

Table 6.36 *Two-sample t-test data for DOiT and Vision question "Today's session impacted positively on my intentions of pursuing an Information Technology major in college"*

	DOiT		Vision	
	Control	Experimental	Control	Experimental
Mean	4.05	3.66	3.67	3.94
t	1.9306		-0.725	
df	37.192		34.278	
p-value	0.9694		0.2367	

t = test statistical value, df = degrees of freedom, *p≤0.05.

6.4.4 Self-concept and Technology Aptitude Mindset

Questions 7 to 10 of the post-survey referred to the variable self-concept, and 11 to 13 to technology aptitude mindset (see Appendix D).

Table 6.31 summarizes the statistical data obtained from the DOiT program participants. There is a special consideration to take into account for questions 10,11 and 13. These questions were phrased negatively. Therefore, a positive attitude will reflect by strongly disagreeing or disagreeing with the statements.

In the case of self-beliefs a positive attitude was considered to be the responses "Agree" and "Strongly Agree", an undecided response was "Neither Agree nor Disagree", and a negative statement was represented by the "Strongly Disagree" and "Disagree" responses.

In the case of mindset a fixed attitude was considered to be the responses “Agree” and “Strongly Agree”, an undecided response was “Neither Agree nor Disagree”, and a non-fixed statement was represented by the “Strongly Disagree” and “Disagree” responses.

The DOiT and Vision self-beliefs results are the following based on the data presented on Table 6.37 and 6.38:

- 85% of the DOiT control group, 90.48% of the DOiT experimental group, 95.24% of the Vision control group and 77.78% of the DOiT experimental group, indicated that they do well in activities that use technology (Question 7: I do well in activities that use technology).
- 65% of the DOiT control group, 52.38% of the DOiT experimental group, 80.95% of the Vision control group and 66.67% of the Vision experimental group stated that they have a lot of self-confidence when it comes to computing courses (Question 8: I have a lot of self-confidence when it comes to computing courses).
- 85% of the DOiT control group, 52.38% of the DOiT experimental group, 85.71% of the Vision control group and 77.78% of the Vision experimental group stated that they are confident they can solve problems using IT applications (Question 9: I am confident that I can solve problems by using Information Technology applications).
- 65% of the DOiT control group, 42.86% of the DOiT experimental group, 52.38% of the DOiT control group and 66.67% of the DOiT experimental

group indicated that they like to use IT to solve problems (Question 10: I do not like using information technology to solve problems).

- 65% of the DOiT control group, 38.10% of the DOiT experimental group, 57.14% of the Vision control group, 61.11% of the Vision experimental group stated that they do not have a fixed level of technology aptitude, and that their technology aptitude could be improved (Question 11: I have a fixed level of technology aptitude, and not much can be done to improve it).
- 100% of the DOiT control group, 85.71% of the DOiT experimental group, 90.48% of the Vision control group and 88.89% of the Vision experimental group agreed or strongly agreed that they can learn new technologies (Question 12: I am able to learn new technologies).
- 85% of the control group, 80.95% of the experimental group, 57.14% of the Vision control group and 72.22% of the Vision experimental group stated that they are able to change theirs basic attitude towards technology (Question 13: I cannot change my basic attitude towards technology).

Table 6.37 *Statistical data of DOiT Self-concept and Technology Aptitude Mindset questions.*

Q	Control						Experimental					
	Self-concept											
	M	SD	D	NAD	A	SA	M	SD	D	NAD	A	SA
7	4.2	-	-	3	10	7	4.14	-	-	2	14	5
8	3.65	-	4	3	9	4	3.62	-	-	10	9	2
9	4.05	-	2	1	11	6	3.62	-	-	10	9	2
10*	4.3	4	9	4	1	2	3.71	3	6	10	2	-
	Technology Aptitude Mindset											
	M	SD	D	NAD	A	SA	M	SD	D	NAD	A	SA
11	2.15	5	8	6	1	-	2.57	4	4	10	3	-
12*	1.77	-	-	-	10	10	2.16	1	1	1	11	7
13	1.65	10	7	3	-	-	1.95	6	11	3	1	-

Q=Question number, M= mean, SD= Strongly Disagree, D= Disagree, NAD= Neither Agree nor Disagree, A= Agree, SA= Strongly Agree. * Likert scale assigned values were inverted.

Table 6.38 *Statistical data of Vision Self-concept and Technology Aptitude Mindset* questions.

Q	Control						Experimental					
	Self-concept											
	M	SD	D	NAD	A	SA	M	SD	D	NAD	A	SA
7	4.19	-	-	1	15	5	4	1	-	3	8	6
8	4.05	-	1	3	11	6	3.7	1	1	4	8	4
9	4.14	-	-	3	12	6	3.9	1	1	2	8	6
10*	3.67	6	5	7	3	-	3.9	5	7	6	-	-
	Technology Aptitude Mindset											
	M	SD	D	NAD	A	SA	M	SD	D	NAD	A	SA
11	2.57	4	8	5	1	3	2.5	3	8	3	3	1
12*	1.76	-	1	1	11	3	1.8	-	-	2	10	6
13	2.38	3	9	7	2	-	2.1	5	8	3	2	-

Q=Question number, M= mean, SD= Strongly Disagree, D= Disagree, NAD= Neither Agree nor Disagree, A= Agree, SA= Strongly Agree. * Likert scale assigned values were inverted.

6.4.5 Correlational Statistics

The main goal of the correlation analysis is to determine if the variables of self-concept and technology aptitude mindset (self-beliefs) are related to the interest variable. Devore (2012) has stated the correlation coefficient as the following: "(r) is the degree of linear relationship between the variables" (p. 510).

Table 6.39 *DOiT correlation coefficient for control group and experimental group*.

	DOiT	
	Control r	Experimental r
Interest-Self concept	0.5096655**	0.3615334*
Interest- Technology Aptitude Mindset	-0.2886094*	-0.3662232*

*r≤0.5, **0.5<r<0.8

Table 6.40 *Vision correlation coefficient for control group and experimental group*.

	Vision	
	Control r	Experimental r
Interest-Self concept	0.3481941*	0.7774332**
Interest- Technology Aptitude Mindset	0.1991977*	-0.2097131*

*r≤0.5, **0.5<r<0.8

Devore (2012) stated that a weak relationship exists when the absolute value of the correlation coefficient is less or equal to 0.5, moderate when it is between 0.5 and 0.8, and strong when it is equal or greater than 0.8.

The relation between interest and self-concept is classified as weak for the DOiT control group and DOiT experimental group (Table 6.39). Figure 6.31 and 6.32 graphically shows the relationship, R^2 and the tendency line's equation. The figures show

a positive relationship, which means that if the interest increases the self-concept also does. In this case the regression model (y = 0.3486x + 3.0275) explains at most 25.9% (R^2 = 0.25976) of the observations.

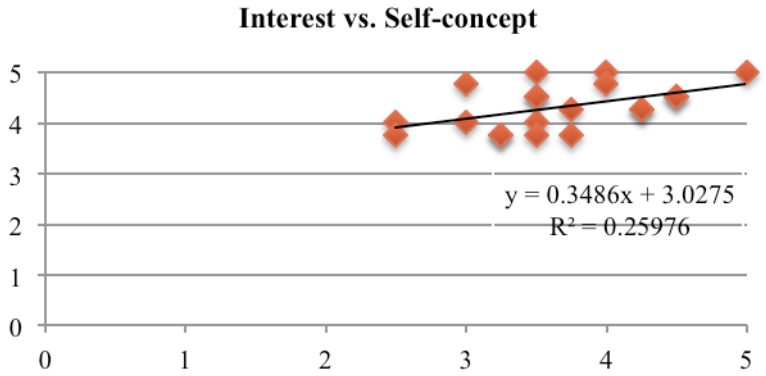

Figure 6.31 DOiT's control group Interest- Self-concept correlation.

In the DOiT's experimental group case the regression model (y = 0.3632x + 2.2398) explains at most 13.07% (R^2 = 0.13071) of the observations.

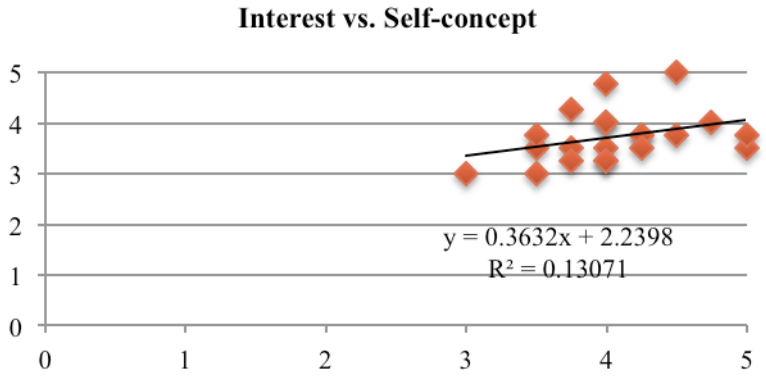

Figure 6.32 DOiT's experimental group Interest- Self-concept correlation.

The relation between interest and self-concept is classified as weak for the Vision control group and moderate Vision experimental group (Table 6.40). Figure 6.33 and 6.34 graphically shows the relationship, R^2 and the tendency line's equation. The figures show a positive relationship, which means that if the interest increases the self-concept

also does. In the Vision's control group case the regression model (y = 0.2133x + 3.1894) explains at most 12.12% (R^2 = 0.12124) of the observations.

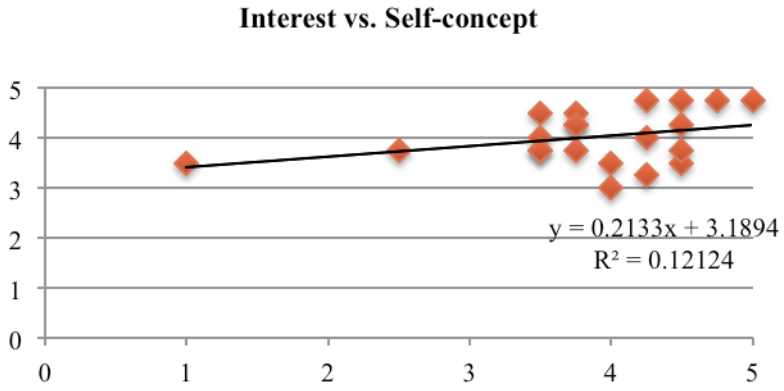

Figure 6.33 Vision's control group Interest- Self-concept correlation.

In the Vision's experimental group case the regression model (y = = 0.801x + 0.7546) explains at most 60.44% (R^2 = 0.6044) of the observations.

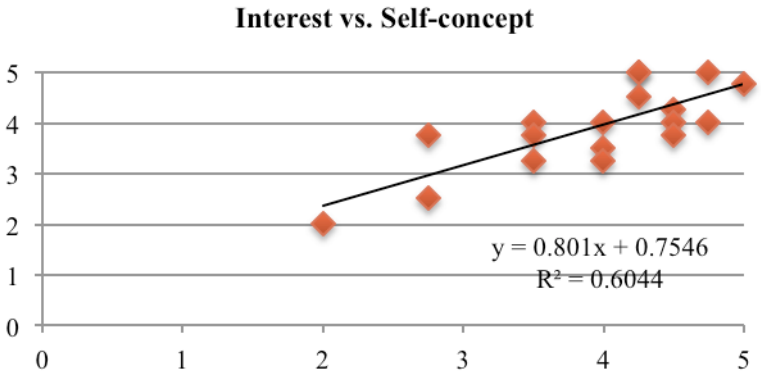

Figure 6.34 Vision's experimental group Interest- Self-concept correlation.

The relation between interest and technology aptitude mindset is classified as weak for both DOiT groups (Table 6.32). Figure 6.35 and 6.36 graphically represent the relationship and display the R^2 and the tendency line equation. The figures show a negative relationship for the DOiT's control group and experimental group. A negative

relationship means that if the interest increases the mindset decreases. In the DOiT's control group case the regression model (y = -0.1896x + 2.4587) explains at most 8.21% (R^2 = 0.08214) of the observations.

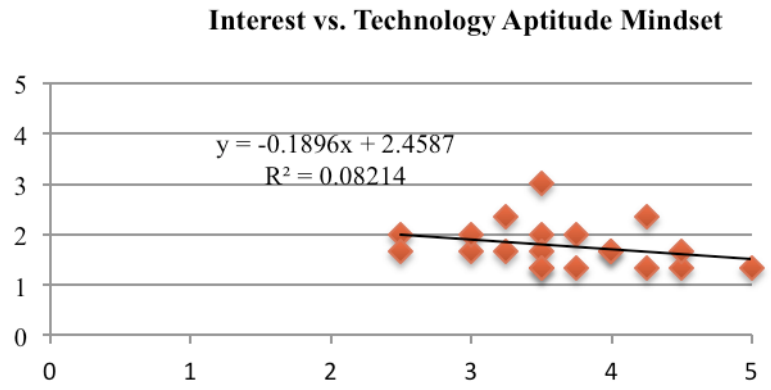

Figure 6.35 DOiT's control group Interest- Technology Aptitude Mindset.

In the DOiT's experimental group case the regression model (y = -0.5277x + 4.3011) explains at most 13.45% (R^2 = 0.13458) of the observations.

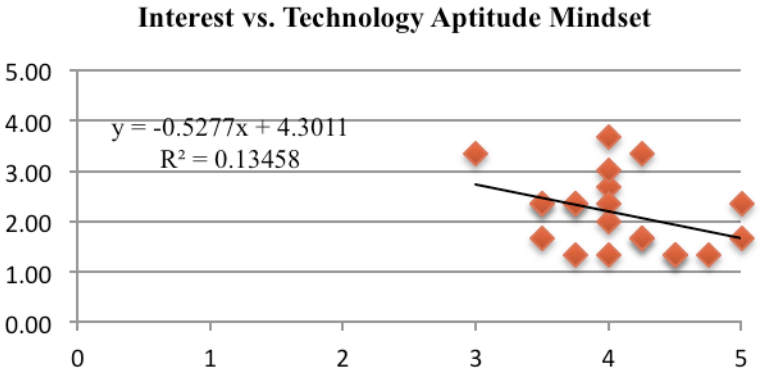

Figure 6.36 DOiT's experimental group Interest- Technology Aptitude Mindset.

The relation between interest and technology aptitude mindset is classified as weak for both Vision groups (Table 6.40). Figure 6.37 and 6.38 graphically represent the relationship and display the R^2 and the tendency line equation. The figures show a

positive relationship for the Vision's control group and a negative one for experimental group.

In the Vision's control group case the regression model (y = 0.1719x + 1.5751) explains at most 4.01% (R^2 = 0.0401) of the observations.

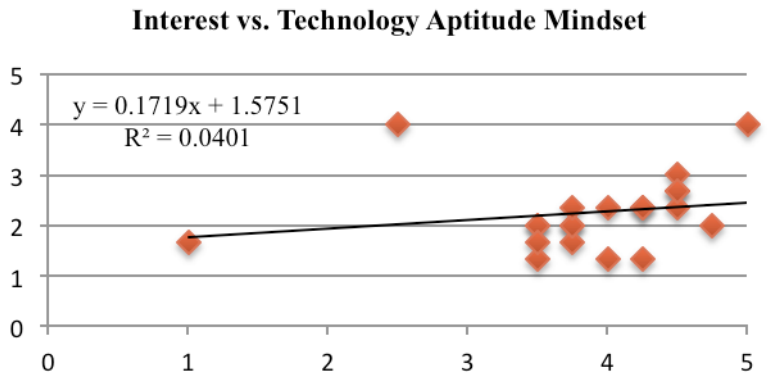

Figure 6.37 Vision's control group Interest- Technology Aptitude Mindset.

In the Vision's experimental group case the regression model (y = - 0.154x + 2.735) explains at most 4.432% (R^2 = 0.04432) of the observations.

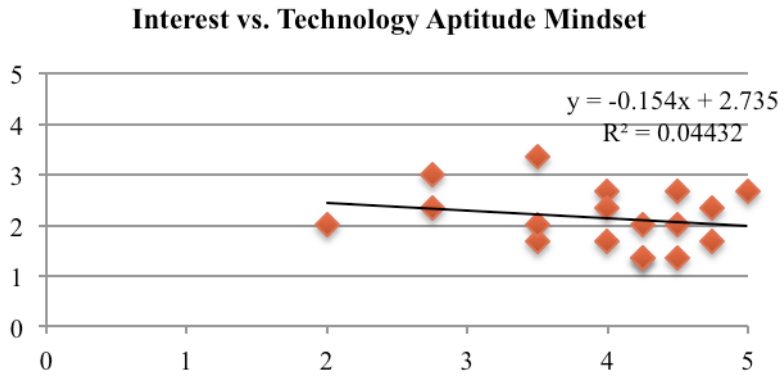

Figure 6.38 Vision's experimental group Interest- Technology Aptitude Mindset.

6.5 Qualitative Analysis of Open Ended Questions

Two open-ended questions related with session feedback were included in the post survey. The responses were manually grouped by topic.

Table 6.41 summarizes the DOiT responses for question 20 "Name one important take-away from this session."

The following are actual responses, spelling was not corrected or altered, assigned to each category:

- Nothing: "None."
- IT careers: "That Computer Technology has a broad range of sub fields from computer/hacking security prevention to fighting diseases in other countries!"
- Hands-on: "I learned about a new form of programming that I can use everyday."
- IT applications: "Information Technology is used everywhere in everyday lives of most people."
- Presenter: "Speaker has soft voice."
- Empowerment: "Anyone can pursue a career in Information Technology."

Table 6.41 *Responses, to question "Name one important take-away from this session", categorized by subject.*

Responses	DOiT Control	DOiT Experimental	Vision Control	Vision Experimental
Nothing	-	1	1	-
IT careers	5	4	8	4
Hands-on	7	8	5	5
IT applications	6	6	4	5
Presenter	-	1	-	-
Empowerment	2	1	-	-

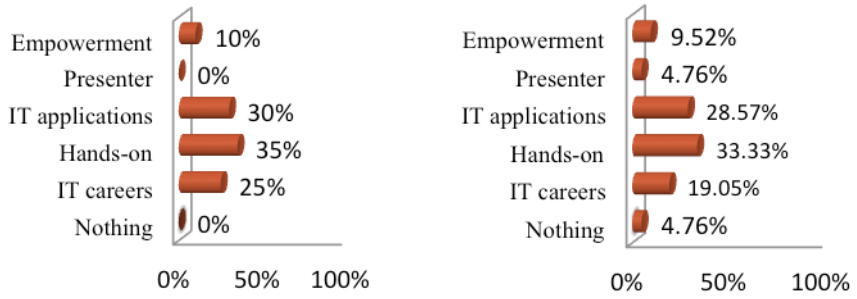

Figure 6.39 Question 20, "Name one important take-away from this session", DOiT (left) control group, (right) experimental group.

The "Hands-on" activity was the most popular category in both DOiT treatment groups (see Table 6.41 and Figure 6.39).

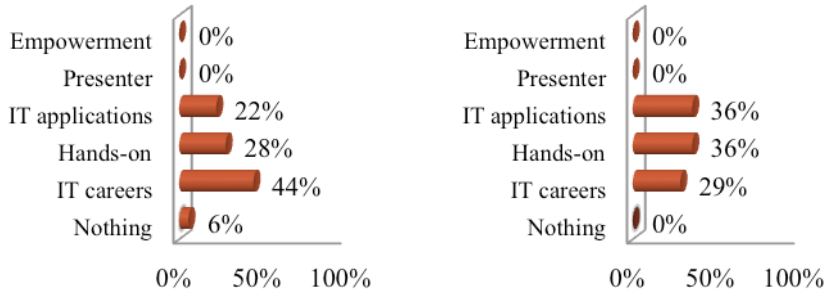

Figure 6.40 Question 20, "Name one important take-away from this session", Vision (left) control group, (right) experimental group.

"IT careers" was the most popular category for the Vision Control group. On the other hand "IT applications" and the "Hands on" were the most popular categories in the experimental group (see Table 6.41 and Figure 6.40).

For question 21 "Name one thing that can make this session better" the responses were categorized based on the feedback topic (see Table 6.42).

The following are actual responses, spelling was not corrected or altered, assigned to each category:

- Lecture: "More interactive slide show at the beginning (kind of boring)."
- Technology: "If we could use the programming on an actual object."
- Presenter: "The instructions could have been given slightly slower."
- Hands-on: "More hands on."
- Time: "If the session was longer I would have liked to attempt something a little bit more complicated."
- Give-away: "Food."
- Nothing: "It was good."

The DOiT control group provided most of its feedback on the "Hands-on" (35%). On the other hand, the most participants in the DOiT experimental group indicated that the category "Lecture" could be improved (see Figure 6.41).

Table 6.42 *Responses for question "Name one thing that can make this session better".*

Responses	DOiT Control	DOiT Experimental	Vision Control	Vision Experimental
Lecture	3	6	1	2
Technology	3	2	-	-
Presenter	4	3	6	4
Hands-on	7	3	7	6
Time	1	4	2	-
Give-away	1	-	-	-
Nothing	1	3	2	3

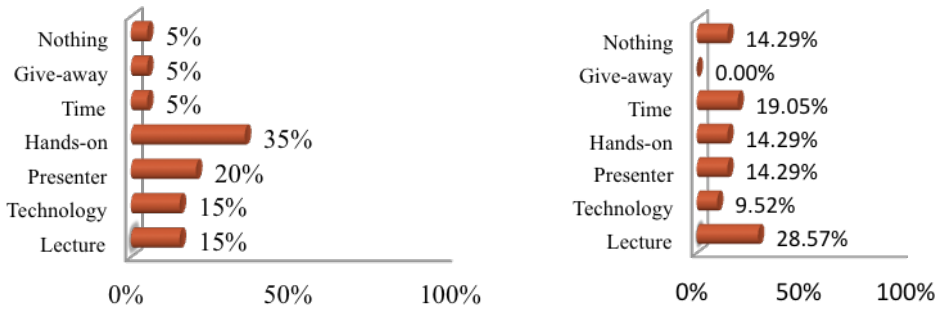

Figure 6.41 Question 21, "Name one thing that can make this session better", DOiT (left) control group, (right) experimental group.

The Vision control group and experimental provided most of its feedback on the "Hands-on" (Figure 6.42).

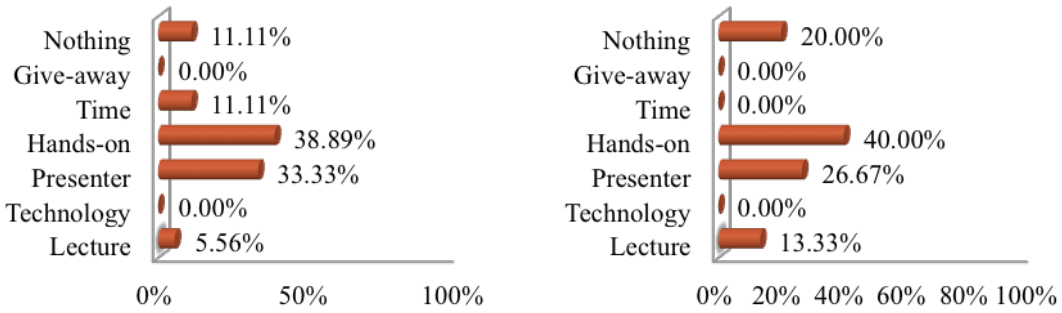

Figure 6.42 Question 21, "Name one thing that can make this session better", Vision (left) control group, (right) experimental group.

CHAPTER 7. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

7.1 Discussion

It is important to early engage students into pursuing IT degrees before they choose a different major. Once this decision has been made is improbable to change the student choice (Akbulut & Looney, 2007). The researcher has been involved in outreach for the CIT department for over two years. During this time, several outreach activities had been developed and implemented with a variety of IT tools. Such as:

- Twitter, a social media tool, successfully implemented as a game to engage Ecuadorian and American teenagers in STEM (Mendez & Serrano, 2013).
- Arduino board coupled with Scratch for Arduino were used to create a punching-pad device, which recorded skin temperature data and punch accuracy.
- nanoNavigator, a flowchart programming tool, coupled with Nanoline components were used to develop an exergaming prototype (Harriger & Serrano, 2014).

All these tools were used to engage students in IT, however, until now all the input gathered was not used to scientifically assess the impact of the sessions.

The results presented in chapter 6 were used to determine the outcome of the outreach sessions carried out in the DOiT and Vision programs held at Purdue University during Spring 2015. The focus of the study was shaped by three research questions raised at the beginning of the research:

1. Does interacting with a physical device programmed by the student increase his/her interest in pursuing Information Technology fields of study?
2. What are students' self-beliefs about Information Technology?
3. What is the relationship between students' interest in Information Technology fields and their self-beliefs?

Answering these research questions will strengthen student IT recruitment and provide valuable input on the outreach activities implemented by the CIT department.

7.1.1 Participation Rate

The DOiT participation rate was of 70.17%, the Vision rate was of 68.42%. This is considered a high response rate and indicates that the study results have a lower risk of having low validity (Morton, Bandara, Robinson, & Atatoa Carr, 2012).

In a research project it is improbable to have a 100% participation rate. Baruch (1999) stated that missing responses could be given due to: (1) responders did not receive the survey or (2) participants do not wish to respond. However, during this study the researcher experienced a problem associated the software used to administrate the surveys; some participants were not able to submit their responses. This is one factor that should be taken into account when working with on-line survey software.

7.1.2 Interest in Information Technology

Based on the data obtained from the pre-survey versus post survey paired t-test, DOiT's control group and experimental group, and Vision's control group increased their overall interest in IT after attending the outreach session. Statement that agrees with previous research indicating that outreach events that use programming and physical computing in an explorative manner have a positive effect in participants' attitude towards computing (Lakanen, Isomöttönen, & Lappalainen, 2012). On the other hand, Vision's experimental mean did not change after the session, participants seemed a little more tired than the previous group.

Interest is an important factor in the SCCT framework, because this emotion stimulates attention, curiosity, and concern towards a specific career. Students that show interest in a specific career or major are more likely to set specific goals to elect it (Akbulut & Looney, 2007).

The data obtained by the two-sample t-test applied to the interest data from the DOiT and Vision control group against experimental group showed that there is not sufficient evidence to reject the null hypothesis of the first research question, there is not statistical difference between the two treatments. In other words, interest rise in the control group is statistically similar to the one experimental group. This could be given due to the fact that all the participants were able to individually interact with the simulation activity. The nanoNavigator simulation tool allows easy manipulation of variables (inputs/outputs), users become active part of knowledge acquisition (Harriger & Serrano, 2014).

In this case, the hands-on activity was composed by the program creation, and simulation in which students were active part by coding and testing the program.

Simulations help participants test predictions and hypotheses; this process improves conceptual understanding of the phenomenon (Rutten, van Joolingen, & van der Veen, 2012). Additionally, in the case of the experimental group, the interaction with the cyberphysical device involved four to eight students who actively interacted while the rest watched. In addition, the cellular reception in the designated laboratory prevented the GSM module to achieve appropriate connectivity; participants interacted with the technology using the operator's panel. Fernández, Villena, and Delgado (2010) stated that 70% of people remember what they say or write and 90% remember what they do, while 20% remember what they hear and 30% what they see. Thus the simulation impact is grater than the one achived with a passive interaction with the cyberphysical device.

Intention of the students to pursue IT was not altered by the session for DOiT's control group, DOiT's control group, and Vision's experimental group. However, Most of the students identified IT careers as an option. On the other hand, there was an increase on the intent towards pursuing IT careers on the Vision's control group after the session.

The session had a remarkable effect on the DOiT control's intention to pursue a career on the field of Technology.

Nevertheless, there was not statistical difference on the overall interest and intent between treatments by the end of both sessions of DOiT and Vision. In other words, booth session's intent data was similar by the end of the session.

7.1.3 Self-beliefs

Self-beliefs are fundamental factors in CVTAE framework, student specific self-appraisals shape particular emotions associated to an activity (Scott & Ghinea, 2014).

This research focuses on self-concept and mindset related with IT. The DOiT and Vision control groups had a higher self-concept compared to the experimental group. Self-perceptions are acquired over time and are related to personality, social and cultural antecedents (Pekrun, 2006). The participants shared similar social and cultural antecedents, based on the demographic data obtained; this behavior then could be attribute to the participant's personality or to the lack of positive reinforcement events related to IT.

The data also shows that of both treatment groups belief that their IT capabilities could be improved or developed by practice. Scott and Ghinea (2014), labeled this type of mindset as "growth mindset". This type of mindset translates to less anxiety consequently evading avoidance behavior.

7.1.4 Relationship between Interest in IT and self-beliefs

Based on the data obtained, the linear relationship between "*Interest and Self-concept*" was a positive weak relationship for DOiT's experimental group, and Vision's control group. DOiT's control group and Vision's experimental group showed a moderate relationship.

The linear relationship between "*Interest and Technology Attitude Mindset*" was weak for all treatment groups. It was negative for DOiT's control group, DOiT's experimental group, and Vision's experimental. Vision's control group was positive.

Although self-concept and mindset fail to directly influence interest in IT careers, except on DOiT's control group and Vision's experimental self-concept, this does not mean that both factors are not relevant in the career decision outcome. It is important to

have in mind that the correlation coefficient (r) only indicates that the relationship in not entirely linear, it is possible that a nonlinear relationship still exists.

For the observations that adjust to the to the linear regression model, the research showed that the interest relates positively with the self-concept and negatively with the technology attitude mindset. Students are more prone to pursue IT fields when they feel confident about their capabilities. Observations that agree with reach conducted on other self-perception factors, such as self-efficiency studied by Akbulut and Looney (2007). On the other hand, a fixed mindset level can be linked to anxiety and evasion (Scott & Ghinea, 2014). Statement that complies with the relationship found.

7.2 Limitations

- The number of instructors available restricted this research. Even though the instructor answered all the questions and helped students that requested help, it was not possible to carefully guide and track individual performance.
- This research was limited by the small sample size.
- One cyberphysical device was available for the interaction on each session. This limited participants' contact with the technology. A reduced amount of students had the opportunity to play the game and interact with the physical components.
- The location of the laboratory negatively impacted the planned use of the GSM module during the outreach sessions.
- The time allowed for the outreach session was an important constraint on active participant interaction.

7.3 Recommendations

7.3.1 Implications for teaching and learning with cyberphysical systems

The number of devices available to use in the session limited participants' interaction in the research. Increasing the number of devices would increase participant active interaction.

7.3.2 Implications for the design of STEM outreach programs

Outreach program design should incorporate active and engaging activities. Passive interaction by itself is not enough to grasp student attention; the instructor should properly guide activities and provide continuous advice.

Additionally, it is important to design the activities taking into account the available time, facilities and personnel available.

7.3.3 Implications for social/educational research

Responses were collected right at the end of the outreach session. It might be important to assess the long-term effects of the outreach; to carry out a longitudinal study would be appropriate.

Even though demographic data about the population was collected it was not used to infer any career related research. A deeper analysis might help to better understand effect of these factors on the career outcome.

7.4 Conclusions

By understanding the factors that influence interest in IT is possible to enhance outreach sessions' activities and improve the probability of future recruitment. This research suggests that the additional interaction, during the outreach session, with a single

cyberphysical device did not increase the interest in IT when comparing it to a session that used only the simulation tool to visualize the outcomes.

Positive accomplishments, channeled as outreach activities, could help strengthen self-beliefs related to IT and technology-related fields, and then increasing the probability of students pursuing IT careers.

Interest in IT does not strongly relates with neither self-concept nor technology attitude mindset linearly. However, a nonlinear relationship cannot be discarded.

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LIST OF REFERENCES

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APPENDICES

Appendix A “Push-up contest” Flowchart

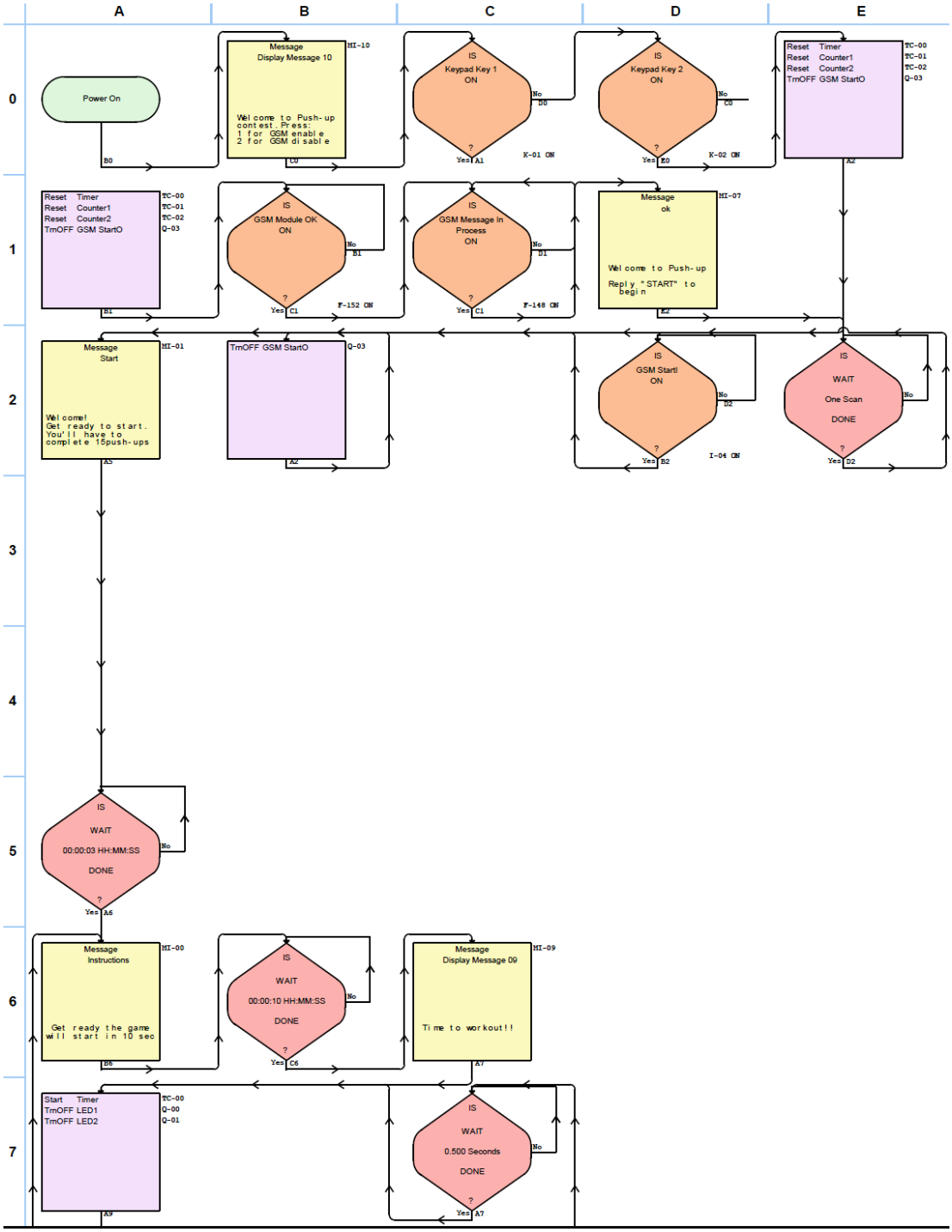
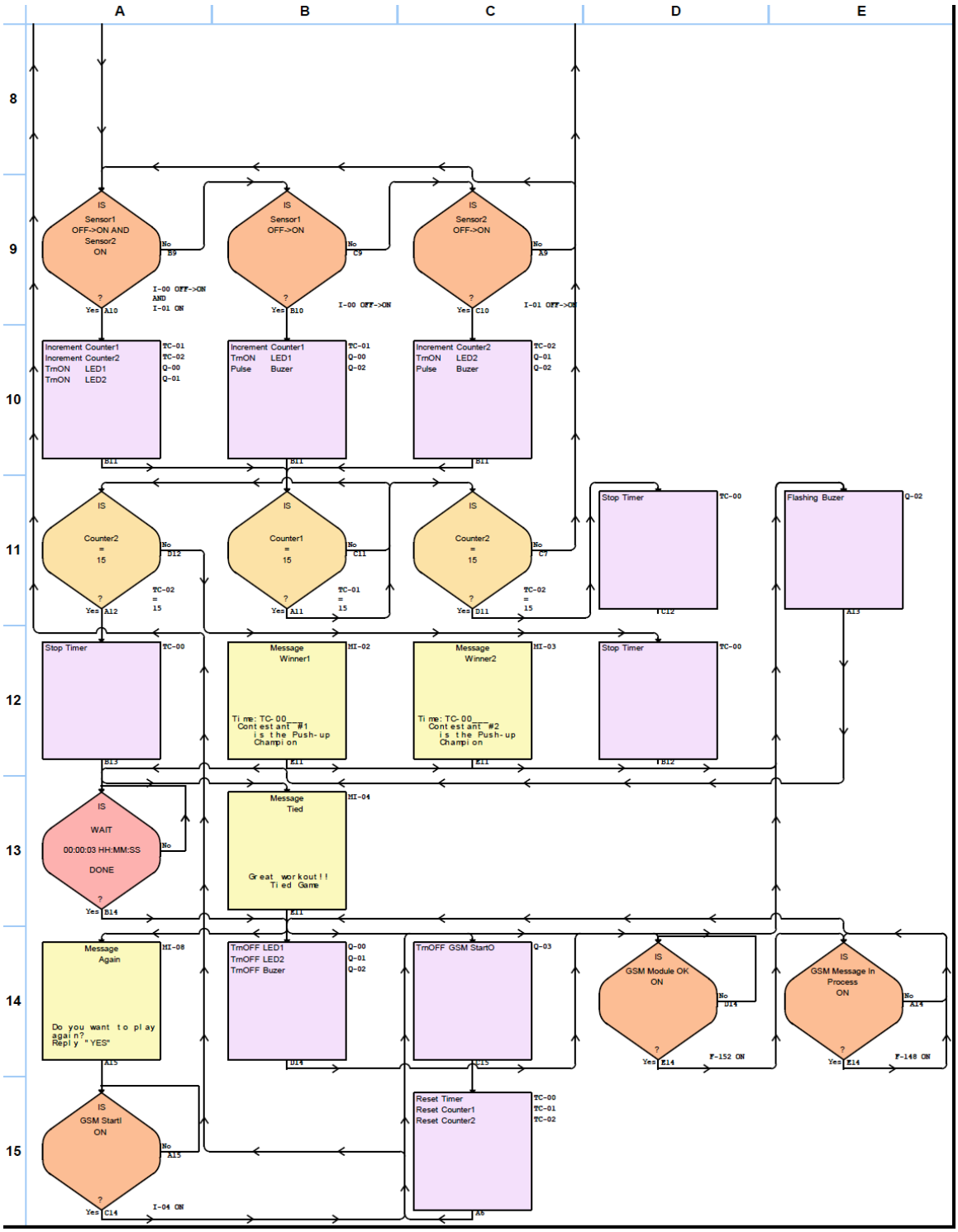


Figure A.2 Flowchart program used in the “Push-up” game device.

Figure A.1 Continued.



Appendix B Device Circuit Diagram

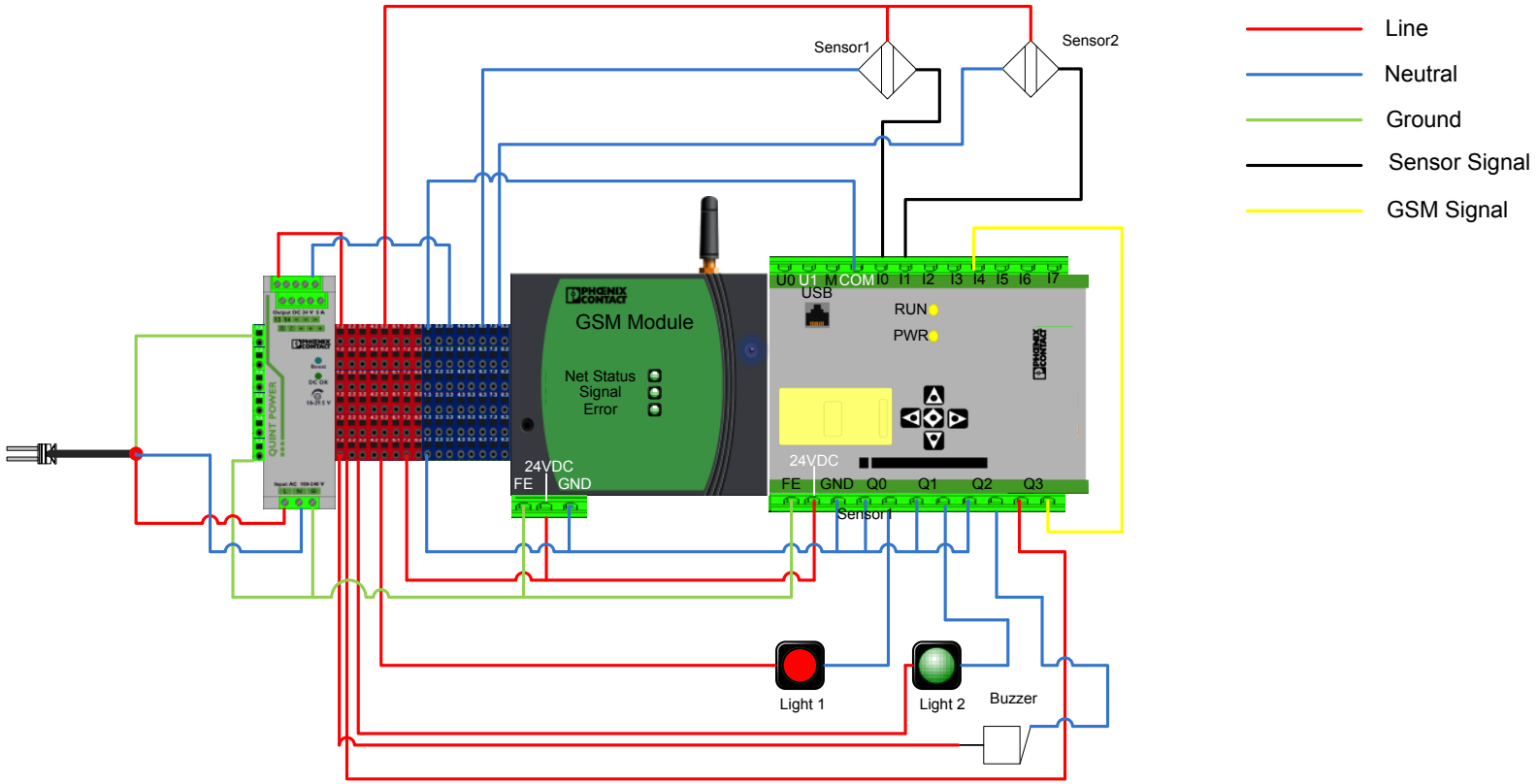


Figure B.2 "Push-up" device's electric circuit diagram.

Appendix C Pre-survey

Outreach Pre-survey

Please answer the following questions:

Please provide your assigned 5-digit ID:

Please indicate to what extent do you agree with the following statements:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I'm familiar with Information Technology.	○	○	○	○	○
2. I'm interested in careers from the Information Technology field.	○	○	○	○	○
3. I use Information Technology daily.	○	○	○	○	○
4. I think Information Technology is interesting.	○	○	○	○	○

Please answer the following questions:

	No	Maybe	Yes
5. Do you plan to attend college?	○	○	○
6. Do you have a role model who uses Information Technology in his/her career?	○	○	○
7. Do you plan to pursue an Information Technology career?	○	○	○
8. Do you plan to pursue a technology related career?	○	○	○

9. What grade are you currently enrolled?

- ○ 10th Grade
- ○ 11th Grade
- ○ 12th Grade

10. What is the highest education level of your father?

- ○ Middle school or below

- ◯ High school
- ◯ Community college
- ◯ Four-year college
- ◯ Masters level
- ◯ Doctorate level
- ◯ Other

11. What is the highest education level of your mother?

- ◯ Middle school or below
- ◯ High school
- ◯ Community college
- ◯ Four-year college
- ◯ Masters level
- ◯ Doctorate level
- ◯ Other

12. What is your race/ethnicity?

- ◯ White/Caucasian
- ◯ African American/Black
- ◯ Native American
- ◯ Hispanic/Latino
- ◯ Asian
- ◯ Pacific Islander
- ◯ Multiracial
- ◯ Other

13. What is your gender?

- ◯ Male
- ◯ Female

Appendix D Post-survey

Outreach Post-survey

Please answer the following questions:

Please provide your assigned 5-digit ID:

Please indicate to what extent do you agree with the following statements:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I'm familiar with Information Technology.	○	○	○	○	○
2. I'm interested in careers from the Information Technology field.	○	○	○	○	○
3. I use Information Technology daily.	○	○	○	○	○
4. I think Information Technology is interesting.	○	○	○	○	○
5. I plan to use technology in my future career.	○	○	○	○	○
6. If I study Information Technology in college, I will be able to pursue many different types of careers.	○	○	○	○	○
7. I do well in activities that use technology.	○	○	○	○	○
8. I have a lot of self-confidence when it comes to computing courses.	○	○	○	○	○
9. I am confident that I can solve problems by using Information Technology applications.	○	○	○	○	○
10. I do not like using information technology to solve problems.	○	○	○	○	○
11. I have a fixed level of technology aptitude, and not much can be done to improve it.	○	○	○	○	○
12. I am able to learn new technologies.	○	○	○	○	○
	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
13. I cannot change my basic attitude towards technology.	○	○	○	○	○

14. This session was informative.	○	○	○	○	○
15. This session was fun.	○	○	○	○	○
16. This experience incremented my interest in Information Technology.	○	○	○	○	○
17. Today's session impacted positively on y intentions of pursuing an Information Technology major in college.	○	○	○	○	○

18. Do you plan to pursue an Information Technology career?

- ○ No
- ○ Maybe
- ○ Yes

19. Do you plan to pursue a technology related career?

- ○ No
- ○ Maybe
- ○ Yes

Please answer the following questions:

20. Name one important take-away from this session.

21. Name one thing that can make this session better.

Appendix E IRB Exemption

PURDUE UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	ALKA HARRIGER KNOY 243
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	02/13/2015
Committee Action:	**Exemption Granted**
IRB Action Date:	02/13/2015
IRB Protocol #:	1412015518
Study Title:	Implementing Information Technology Tools in Outreach

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b)(1) .

If you wish to make changes to this study, please refer to our guidance "**Minor Changes Not Requiring Review**" located on our website at http://www.irb.purdue.edu/policies.php. For changes requiring IRB review, please submit an **Amendment to Approved Study** form or **Personnel Amendment to Study** form, whichever is applicable, located on the forms page of our website www.irb.purdue.edu/forms.php. Please contact our office if you have any questions.

Below is a list of best practices that we request you use when conducting your research. The list contains both general items as well as those specific to the different exemption categories.

General

- To recruit from Purdue University classrooms, the instructor and all others associated with conduct of the course (e.g., teaching assistants) must not be present during announcement of the research opportunity or any recruitment activity. This may be accomplished by announcing, in advance, that class will either start later than usual or end earlier than usual so this activity may occur. It should be emphasized that attendance at the announcement and recruitment are voluntary and the student's attendance and enrollment decision will not be shared with those administering the course.
- If students earn extra credit towards their course grade through participation in a research project conducted by someone other than the course instructor(s), such as in the example above, the students participation should only be shared with the course instructor(s) at the end of the semester. Additionally, instructors who allow extra credit to be earned through participation in research must also provide an opportunity for students to earn comparable extra credit through a non-research activity requiring an amount of time and effort comparable to the research option.
- When conducting human subjects research at a non-Purdue college/university, investigators are urged to contact that institution's IRB to determine requirements for conducting research at that institution.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without

proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 1

- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Categories 2 and 3

- Surveys and questionnaires should indicate
  - only participants 18 years of age and over are eligible to participate in the research; and
  - that participation is voluntary; and
  - that any questions may be skipped; and
  - include the investigator's name and contact information.
- Investigators should explain to participants the amount of time required to participate. Additionally, they should explain to participants how confidentiality will be maintained or if it will not be maintained.
- When conducting focus group research, investigators cannot guarantee that all participants in the focus group will maintain the confidentiality of other group participants. The investigator should make participants aware of this potential for breach of confidentiality.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 6

- Surveys and data collection instruments should note that participation is voluntary.
- Surveys and data collection instruments should note that participants may skip any questions.
- When taste testing foods which are highly allergenic (e.g., peanuts, milk, etc.) investigators should disclose the possibility of a reaction to potential subjects.

Appendix F Interaction Diagrams

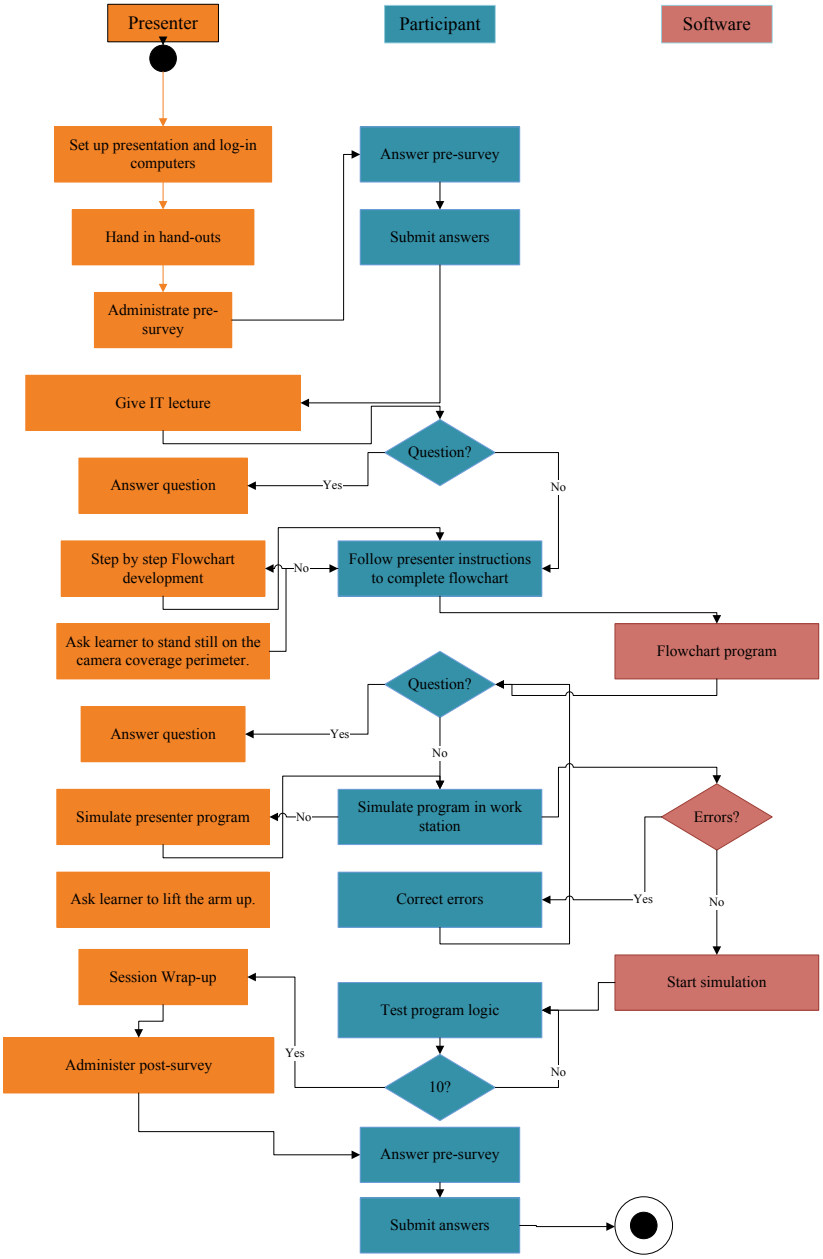


Figure F.2 Control group interaction diagram.

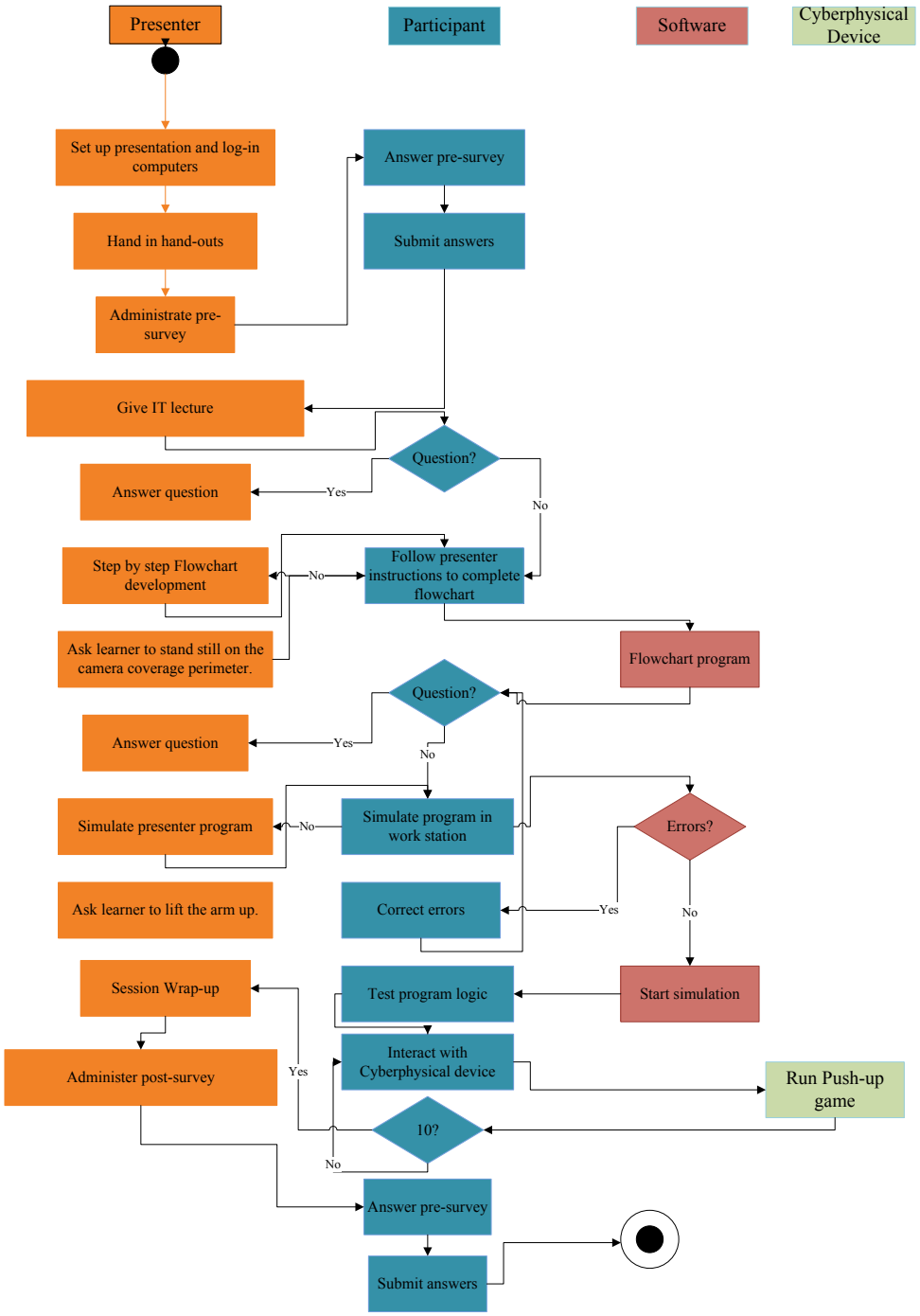


Figure F.2 Experimental group interaction diagram.